

**WEB-ENABLED PROJECT MANAGEMENT AND COLLABORATION USING
MICROSOFT GROOVE SYSTEM**

A Thesis

by

KAMER YUKSEL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2008

Major Subject: Construction Management

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ABSTRACT

Web-Enabled Project Management and Collaboration Using
Microsoft Groove System. (August 2008)

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In every construction project, there is involvement of multiple team-players and their individual efforts have to be coordinated in a timely manner. Sharing and synchronizing information exchange among diverse team players requires a comprehensive project management and collaboration system that is easily accessible and manageable. Web-based or web-enabled project management and collaboration software offer several opportunities for this purpose.

In the last decade, the construction industry has realized the necessity of adopting project management and collaboration systems but experienced adaptation and implementation problems. The major reasons were the required software knowledge, training and comfort level of the users. These issues can be addressed by utilizing a software package that provides a familiar user interface and flexible customization options.

Microsoft Groove provides an alternative for web-enabled project management and collaboration with comprehensive and customizable tools, while maintaining the familiar Microsoft Office look and feel. This thesis compares the features of Groove software to commonly used project management and collaboration systems in the construction industry. A sample Groove workspace is developed and demonstrated with customized modules and templates for a typical construction project.

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NOMENCLATURE

AEC	Architecture, Engineering, and Construction
AGC	Associated General Contractors of America
AIA	American Institute of Architects
ASP	Application Service Provider
CFMA	Construction Financial Management Association
EDA	Electronic Data Interchange
FTP	File Transfer Protocols
IT	Information Technology
NSPE	National Society of Professional Engineers
PMCS	Project Management and Collaboration Systems
RFI	Request for Information
RFP	Request for Proposal
RFQ	Request for Quotes
ROI	Return on Investment

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1 INTRODUCTION

Construction projects are unique and complex in nature. The complexity arises from the involvement of multiple team-players and the necessity to timely coordinate these individual efforts toward a common goal: the successful completion of the project. Successful completion of a project is not possible unless all the parties communicate accurately, effectively, and timely, forming and exchanging critical information (Becerik, 2006). Sharing and synchronizing information exchange among diverse team players requires a comprehensive, easily accessible, and manageable project management and collaboration system (PMCS). Web-based or web-enabled PMCS offers several benefits for such projects with their fast and reliable data transmission. Their distinct project control capabilities allow for storing, updating, and sharing critical and fragmented information in an organized fashion.

The construction industry, to a certain extent, has realized the necessity of adopting PCMS. In the 2006 Information Technology Survey of CFMA, forty three percent of the construction companies stated that they use project collaboration software in their projects (CFMA, 2006). The same survey also reveals the high adoption rates (98%) of project management software in the construction industry. However, it is important to emphasize that these figures do not reflect utilization level and efficiency of these programs. Research demonstrates that construction professionals are experiencing notable problems with learning and using these programs (Becerik, 2006). FMI's "Contractor Productivity Survey" (2004) noted that sixty five percent of the companies were not able to successfully implement new ideas or lack the ability to sustain them very long. These observations suggest that while the construction industry is investing in new technologies and ideas, it is experiencing adaptation and implementation problems.

This thesis follows the style of *Journal of Planning Education and Research*.

The major reasons for the adaptation and implementation problems are the required software knowledge, training, and comfort level of the users. It should be noted that the software companies in the market have not fully managed to develop comprehensive and industry-tailored software packages, which are at the same time user-friendly and flexible for customization. These issues can be addressed by utilizing a software package that provides a familiar user interface and flexible customization options.

This study focuses on demonstrating an alternative tool for project management and collaboration, Microsoft Office Groove. Microsoft Groove became a part of the standard Microsoft Office package in their 2007 release. It provides an alternative for web-enabled project management and collaboration with comprehensive and customizable tools, while maintaining the familiar Microsoft Office look and feel. This study explores the potential applications of management and collaboration for a typical construction project using Groove software. The following sections of this thesis include the goals and objectives, the review of related literature, the methodology, as well as the template development for a typical construction project using Groove system.

2 GOALS AND OBJECTIVES

The goal of this study is to demonstrate Microsoft Groove as an alternative project management and collaboration tool for construction projects. To accomplish this goal, the following specific objectives are completed:

- Identification of the commonly used web-based and web-enabled PCMS in the construction industry and their potential areas of improvement.
- Development of Microsoft Groove template for a typical construction project
- Demonstration of Microsoft Groove's structure by applying the developed template to a real-life construction project

3 BACKGROUND AND LITERATURE REVIEW

This section presents a summary of the related research on project communication and collaboration including a discussion on the new technology adoption and diffusion in the construction industry, and barriers to adoption of new technologies. A review of the literature on current PCMS in the construction industry with a specific focus on PMCS common properties, and limitations is included. Finally, existing literature on Microsoft Groove system is reviewed.

3.1 ROLE OF COMMUNICATION AND COLLABORATION IN PROJECT SUCCESS

Although there are many factors affecting project success, there is clear evidence that effective communication and collaboration among team players are vital for project success. Communication allows people to understand one another, through the interpretation of sent messages. Some of the widely accepted definitions of communication put forward by Hoyland et al. (1953) and Ruesch and Bateson (1961) (as cited in Miller, 2004) state that communication is “the process by which an individual transmits stimuli to modify the behavior of other individuals” (Hovland et al., as cited in Miller, 2004, p.4) and that “Communication does not refer to verbal, explicit and intentional transmission of messages alone. The concept of communication would include all those processes by which people influence one another” (Ruesch and Bateson, as cited in Miller, 2004, p.4)

Communication theory identifies three major components of communication. For communication to take place there has to be a sender, a receiver, and a message. The message should be transmitted through a medium and the receiver should decode the message in order to understand the meaning. The type of medium is of critical importance in communication because it impacts the decoding process. The decoding of

the message is essential because it represents the meaning that has been assigned to the message by the receiver. Meanwhile, how people understand and interpret things can vary significantly (Miller, 2004). In a project setting, communication problems occur mainly due to the team members' differing ways of speaking and listening (Koskinen, 2004). Barriers and filters also play a major role in the understanding of the real message. Barriers can originate from the current state-of-mind of the receiver, such as bias, prejudice and emotions, as well as due to lack of technical or educational knowledge needed for total understanding (Thomas et al., 1998). Although it is humanly and technically impossible to remove all the barriers to effective communication, setting a system which will formalize and systematize the communication process can help to enhance the project performance by either blocking or mitigating the negative effects of the distortions.

A study conducted by the Construction Industry Institute tried to identify and measure the critical communication variables influencing construction project success (Thomas et al., 1998). The primary aim of the study was to develop a tool which would help enhance communication among project team members (Thomas et al., 1998). In order to achieve this, research team selected critical communication variables as well as certain project success variables such as budget, schedule, and amount of rework, and analyzed the relationships between those variables (Thomas et al., 1998). Their research ranked the critical communication variables which demonstrate a significant correlation with project success as (a) *accuracy* of information provided (b) the existence of well-defined *procedures* outlining the project scope and methods (c) the presence of *barriers* such as interpersonal problems in the communication process (d) thorough *understanding* of the expectations (e) *timely* receipt of critical information and (f) *completeness* of the information received (Thomas et al., 1998).

Another study by Chan et al. (2004) identified the main factors affecting project success. Figure 1 show these critical success factors as project management actions, project procedures, external environment, project-related factors, and human-related factors.

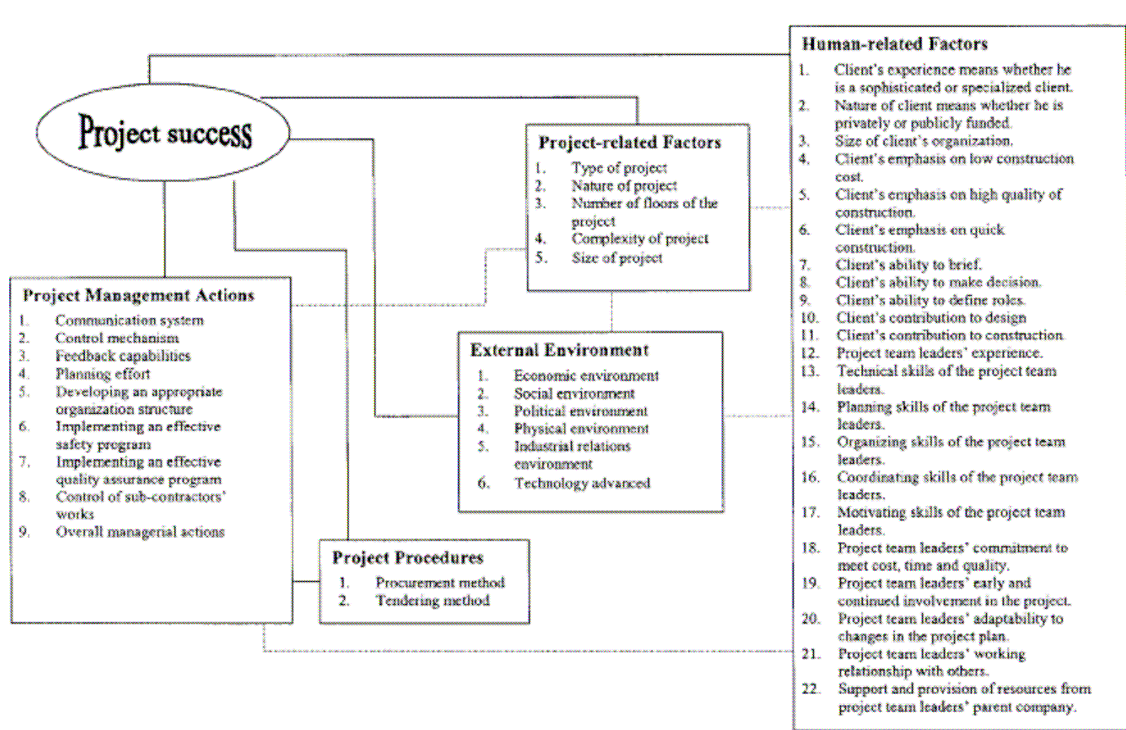


Figure 1. Factors affecting project success (Chan A.P.C, Scott D., & Chan A.P.L, 2004)

As illustrated in Figure 1, authors' classification of project management actions emphasizes the importance of communication, project control, feedback, planning, and organization for the successful completion of the project. These competencies can be enhanced through well-structured and effectively utilized PMCS. In addition to its contributions to project management actions, PMCS can also affect the project success by altering the project procedures from conventional methods to contemporary methods such as e-business and e-finance. Even the relatively robust human-related factors can be affected by the implementation of PMCS. A well-institutionalized, successfully adopted

PMCS can positively influence the team members' planning, decision making, organization, and coordination skills by providing on-time and quality information.

Communication on its own is not enough for project success; high level of collaboration among team members and stakeholders is also mandatory (Laepfle, 2005). When the fragmented nature of the construction industry is considered, the importance of collaboration becomes clear. As Laepfle asserts, "Collaboration is a joint problem solving that is working together with shared goals" (Laepfle, 2005, p.46).

Effective communication is an essential part of collaboration. If stated differently, collaboration mandates communication but the opposite is not necessarily true. Communication can still happen without collaboration among team members, so collaboration can be considered as a step forward in realizing the shared goals by means of more durable relationships and full commitment of the team members (Laepfle, 2005). For collaboration to be lasting, there are certain factors that have to exist as the basis of the relation. According to Lorenz et al. (as cited in Laepfle, 2005), the major components of collaboration are the existence of common purpose, shared paradigm, mutual respect, and effective communication.

In a construction project, common purpose will most likely be the safely and timely completion of the project with an acceptable quality and within budget. Without a purpose there is no reason for collaboration. Shared paradigm, on the other hand, represents the values, methods, and practices commonly accepted by all the team members to achieve a common goal.

Collaboration attempts should not start as a result of disputes and problems while the project progresses, rather the foundation for collaboration should be built before any real problems arise (Larson, 1997). This can be done through team-building processes, which bring the related parties together to clarify the communication and collaboration strategies and how to best handle the conflicts or disputes before they actually happen

(Larson, 1997). Another important factor for successful collaboration is the managements' attitudes, particularly when they are confronting serious problems (Larson, 1997). Their attitudes and behaviors should be consistent with the core values of collaboration, which are trust, openness, and teamwork (Larson, 1997).

Communication and collaboration shortcomings in the workplace are one of the first suspects for low levels of productivity in the construction industry (FMI, 2004). FMI's Construction Industry Productivity Survey highlights communication and collaboration problems as one of the main challenges for improving productivity levels. Figure 2 illustrates the communication and collaboration related challenges for contractors in improving productivity.

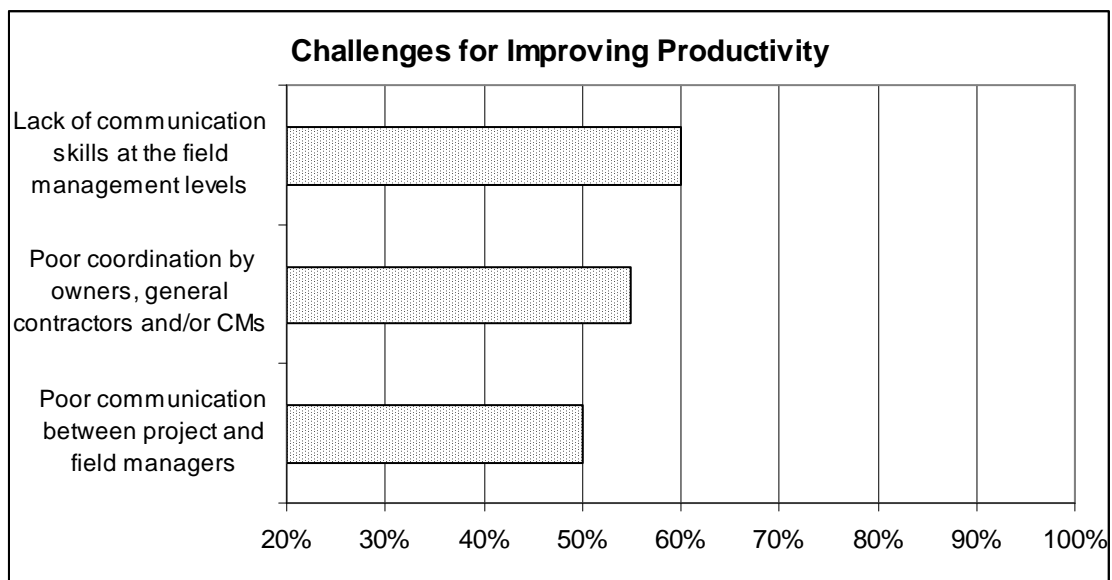


Figure 2. Challenges for improving productivity (Adapted from FMI, 2004)

As shown in Figure 2, survey respondents pointed lack of communication skills (60%) and poor communication between project managers and field managers (50%) as major internal challenges impeding productivity. The same survey also highlighted poor

collaboration between owners, general contractors, and/or construction managers (55%) as one of the external challenges for improving productivity.

3.2 CONSTRUCTION INDUSTRY DATA MANAGEMENT

Construction industry is an information intensive industry. Data that is generated can be grouped either as structured or unstructured data (Caldas et al., 2005). Structured data are generated through a database system which uses a predetermined structure and format (Caldas et al., 2005). This type of structuring brings certain amount of standardization and improves interoperability among computational systems (Caldas et al., 2005). For instance, cost control module in certain PMCS is an example of such structured data. Users have little influence over the system. However, in reality the majority of the documents that are generated in construction projects are unstructured data which is based on text-based documents such as contracts, field reports, change orders, RFIs etc. (Froese, 2003). Although these documents are accepted as unstructured data, today many of the web-enabled and web-based PMCS partially structure these documents as well. For example, Constructware offers standard modules for creating and tracking RFIs, change orders, and daily reports. This enables all team members to view and edit the same standard view of one type of document, hence improving interoperability amongst different computers. However, some researchers argue that this is just a replication of the text-based document on the system and offers no real solutions for handling such complex data (Maoa et al., 2006).

There have been many studies conducted and common data models developed in order to standardize and create one common methodology for handling both the structured and unstructured data in the construction industry. Industry Foundation Class (IFC) standard is one such example. IFC developed by the International Alliance for Interoperability is a global alliance representing more than 600 AEC companies, vendors and software

developers (Froese, 2003). As Froese (2003) states it “IFC is a high-level, object oriented data model for the AEC/FM industry” (p.231).

Construction industry mainly utilizes CAD drawings in AutoCAD format “.dwg”, plot files in “.plt” format, Microsoft Word documents “.doc”, as well as files in Adobe PDF and Microsoft Excel “.xls” formats (Hjelt & Bjork, 2007). These formats serve to two main categories of information (1) contract documents and (2) project management documents (Zhu et al., 2001).

3.2.1 Contract Documents

A contract is a mutually binding agreement which obligates the seller to provide the promised product or service at the same time obligates the buyer to provide monetary or some other form of payment in return (PMI, 2004). Contracts include terms and conditions, a detail description of the product or service as well as the seller’s price proposal for the item/service to be provided (PMI, 2004). Generally construction projects require more than a single contract to initiate the project. The product/service description and scope of work in construction projects are so comprehensive that additional documents should accompany the contract and are considered as part of the contract package. In addition to the Owner-Contractor agreement general conditions of the contract, supplementary general conditions, working drawings and specification, and any addenda if needed are included in the contract package (Dagostino & Feigenbaum, 2003). PMI’s (2004) Project Management Body of Knowledge identifies three main types of contracts which are (a) fixed price or lump sum contracts (b) cost reimbursable contracts and (c) time and material contracts.

In most construction projects, drawings and specifications are part of the contract package and are the primary source of information during construction as well as the litigation if conflicts arise. Working drawings are the actual drawings and illustrations from which the project is built (Dagostino & Feigenbaum, 2003). They display the exact

dimensions and locations of the construction elements in a project as well as the materials needed for these elements and how they all come together (Dagostino & Feigenbaum, 2003). Drawings on its own are not enough to define every single detail in a construction project. Specifications are generally needed. Specifications provide written, pictorial, or graphical information elaborately describing the services or items to be procured (Kerzner, 2003). Specifications fall into one of the three categories:

(a) design specifications (b) performance specifications or (c) functional specifications (Kerzner, 2003).

Since changes are unavoidable in construction projects, they have to be properly planned, managed and controlled. In a construction project changes happen due to a number of reasons such as design errors, additions to the scope of work as requested by the owner, unknown site conditions, force majeure, value engineering, or acceleration (Hanna et al., 2002; O'Brien, 1998). According to American Institute of Architects' 2006 Work On The Boards Survey results, additions to the scope of work by the owner account more than half of the average increase in cost whereas unknown or unforeseen site conditions generally account for more than a quarter of the average cost increase and design errors contribution to cost increase is around 10 percent (AIA, 2006a). AIA survey also reveals that change orders on average cost about four percent of the total construction cost (AIA, 2006a).

The process which organizes and controls the change process in construction is called the change order process. Change Order process may start and proceed in several different ways. A RFI (Request for Information) generally precedes a Change Order or a bulletin can be issued to request for a price from the contractor for the proposed changes (O'Brien, 1998). Managing Change Orders is very critical because in most of the cases, they have an effect on the original contract amount and/or the project completion time agreed upon by the Owner and the Contractor. Change Order process is the only formal process that can authorize a change in the contract time and contract sum, after the

execution of the Contract (TAMU Facilities, 2007). As a result, Change Orders is a major source of conflicts and disputes between the Owner and the Contractor (AIA, 2007). However, despite its complications, most contracts authorize change orders (O'Brien, 1998).

Revisions made to original contract sum and stated on the Change Order form, do not reflect the changes to the Contract sum stem from Change Directives (AIA, 2001a). A Change Directive is different than a Change Order because it directs changes to work without final agreement between the Owner and the Contractor on the proposed changes of the contract sum and time (AIA, 2001b). As a result, Change Directives are filed separately from Change Orders with different identification numbers. Once an agreement on a Change Directive is reached, a Change Order should be issued. In case of disagreement, Change Directives do not prejudice the Contractor's right to make claims and appeal under the terms of the Contract (TAMU Facilities, 2007).

The main project management documents include but are not limited to:

3.2.2 Project Management Documents

Construction project management best practices require certain documents to be generated and updated regularly throughout the project. These documents mainly include RFIs, RFP/RFQs, schedule, budget, and estimates.

RFIs are generally used to clarify issues related to drawings (Zhu et al., 2001). When issuing RFI, certain level of detail should be included and the purpose should be the clarification of unclear, doubtful elements of the project. AIA guides practitioners in RFI content and recommend that RFI must include the following information: project information, project name, project number, RFI information, RFI number, RFI title, initiation date, subject, discipline affected, priority (1 to 5), submission information, submitted by:, coauthor, submitted to:, copies to:, referenced drawing and specification

number, construction manager/general contractor signoff, impact, cost impact (yes/no; dollar amount), Schedule impact: (yes/no; number of days), drawing impact: (yes/no; description), change order required: (yes/no), request, information requested, requested by, date required or ASAP, 1st/2nd/3rd request, proposed solution, response, answered by:, date answered (AIA, 2006b). However, some researches argue that RFI processes have turned into a paper trick in order to gain more time and claim advantages by the contractors (Zack, 1999). There are many instances that RFIs are used in lieu of submittals, to respond to notices of non-conformance, transmit safety plans and schedules (Zack, 1999). The definition of RFI and the specific purpose of it should be explicitly stated in the contract documents in order to avoid misinterpretation or misuse of it.

AIA defines the RFP/RFQ process as requesting from pre-selected suppliers a well-considered proposal of the services or items needed for the construction project. Some organizations refer to an already maintained preferred sellers list which they have established in time through certain qualification methodology (PMI, 2004). A solid RFP or RFQ should include all the items and should address all the points that the owner deems necessary for the well being of the project (Dhokai, 2001). Depending on the item and the specific need RFQ or RFP may include information for the basis of the design, system selection, quality control and assurance, and special instructions (Dhokai, 2001). Organizations may seek for RFQs or RFPs through advertising, negotiation, and/or bidder conferences (Kerzner, 2003; PMI, 2004).

Construction schedule is a graphical representation of the plan (activity definitions, sequencing and durations) which the project will depend upon as the basis of assembling the project (Feigenbaum, 1998). After deciding on how the project will be organized by Work Breakdown Structure, activity definitions are determined, activity sequencing is decided, and activity durations are estimated considering the organizational resource

limitations (PMI, 2004). At this point the project has every input needed to develop the schedule. The two main scheduling methods used are arrow diagramming method and precedence diagramming methods (PMI, 2004). Precedence diagramming method is the most common methodology used to schedule construction projects by the scheduling software such as Primavera Systems and MS Project (Feigenbaum, 1998). Although scheduling is a major component of project time management, when schedules are resource loaded, they also serve to cost management needs of projects. Utilization of scheduling software is considered vital to schedule and manage today's complicated projects. According to Constructech's National Construction Technology Survey more than 79 percent of survey participant contractors believe in the importance and necessity of the use of scheduling software (Constructech, 2006). Right now the most commonly used scheduling softwares in the construction industry are Primavera (74%) and MS Project (24%) (Constructech, 2006).

Project estimates represent the probable construction costs of project or project elements (Feigenbaum, 1998). Cost estimating is developing a cost approximation for all the individual resources (labor, material, equipment etc.) needed to complete schedule activities while considering the possible effects of cost variances and risks (PMI, 2004). Estimates can vary based on the specific accuracy level needed at that stage of the project. A detailed estimate, preliminary or conceptual estimates are types of estimates that can be used at the beginning or at later stages of a project (Feigenbaum, 1998). Detailed estimates require more time and resources compared to other type of estimates which makes them more costly. As a result, it is important to produce the necessary level of detail in any estimate based on the current needs and stage of the project.

Budgets are derived from cost estimates. Cost budgeting involves aggregating the individual cost estimates in order to establish a cost baseline for the project (PMI, 2004). Managing projects using budgets is very important because budgets establish one or

more check points for important milestones and the completion of the project. Budgeting gives a greater control over the project and helps to control one of the triple constraints of construction projects, which is cost. And knowing the people as who they are, it is also known that without specific goals and constraints people tend to achieve or perform less (Locke et al., 1988).

3.3 DRIVERS OF TECHNOLOGY ADOPTION IN THE CONSTRUCTION INDUSTRY

The adoption and diffusion of technological advancements in a certain industry are one of the main external factors that have an impact on project success (Chan et al., 2004). Nevertheless, historically, construction industry is perceived as slow and reluctant in new technology adoption and implementation compared to other industries (Laborde & Sanvido, 1994). Haas et al. (1999) explain the major barriers to adoption of new technology in the construction industry as diverse standards, fragmentation, business cycles, and risk aversion. Relatively low cost of labor in many states is also stated by the authors as one of the main factors which discouraged new technology invention and adoption in the construction industry. Tatum (1989) stresses the associated technological and financial risks, and identifies the risk of rejection by the employees as the main reasons for technology avoidance in the industry.

The technology avoidance in many construction companies is a serious threat to the industry. It is not only affecting the productivity levels of the industry but also feeding the culture which is already resistant to change. Williams et al. (2007) comparatively analyze the advanced information technology adoption patterns both in the U.S and Korea. Their research highlights the low usage of common IT technologies in the 152 US construction companies. More than half of the companies, according to this research, have never utilized web conferencing, web portals, barcode scanning, e-learning, e-bid, GIS (geographic information systems), GPS (geographic positioning systems), or RFID.

Only ten percent of the companies state that they use CAD and web portals a lot (Williams et al., 2007). Similarly, when other technologies such as wireless technology are examined, the adoption rates are similarly very low despite the high perceived benefits of it (Williams et al., 2007). The use of wireless camera and the use of Wi-Fi at the construction sites are slightly higher than 10 and 20 percent, respectively (Williams et al., 2007). Surprisingly, the same survey finds out that Korean construction industry is far ahead of the US construction industry in terms of adoption of these technologies in daily work. Web based computing and wireless technologies are three and two times more frequently used in the Korean construction industry compared to US construction industry (Williams et al., 2007).

One might think that companies big in size have more available resources to invest in new technologies. Nevertheless, Williams et al. (2007) argue that this is not necessarily the case especially for the web-enabled or web-based IT tools. Authors did not find any significant relationship between the company size and the utilization level of technologies such as web portals and CAD. This shows that adoption of online information technology tools does not necessitate significant amount of resources (Williams et al., 2007).

The online information technology tools or web-enabled/web-based PMCS have become more abundant and affordable in recent years. By comparison, the wide and fast adoption of the Internet has influenced how every industry does business and the construction industry is not an exception. There are promising statistics and research showing the increasing trend of IT usage in the construction industry as well.

Mitropoulos and Tatum (2000) with their article “Forces driving adoption of new information technologies” aimed to identify and analyze the external (owner-imposed, competition-imposed etc.) and internal (organizational) factors which influence the rate of technology adoption in the construction industry. Their research focus on eight

companies, three of which are mechanical contractors and two are general contractors. The companies of concern are large organizations with an annual revenue exceeding 100 million dollars. The specific technologies selected by the authors are CAD and Electronic Data Interchange (EDA) technologies. As a result of these case studies, Mitropoulos and Tatum identified the four major triggers for technology adoption as competitive advantage, process problems, technological opportunity, and external requirements. According to the authors, competitive advantage is enhanced if the new technology improves an organizational critical capability and if the competition has not adopted the same technology. Process problems in the case studies are originated from (a) enhanced requirements for better quality and detailed drawings; (b) technologies that are readily used became insufficient to communicate the design; and (c) company growth, which necessitated improved technologies to better serve the bigger-scale and complex projects with more levels of detail. Technological opportunities were identified as improved organizational capabilities due to the availability of young engineers with technologically-advanced backgrounds, existence of complimentary technologies, and the affordability of new technologies. Finally, the major external requirements derived from technological changes were identified as client specifications, rival-pressure, and regulatory enforcements.

In addition to these triggers for technology adoption, there has been a rapid change in the construction environment, which affected the project management practices (Alshawi & Ingirige, 2003). These changes can be summarized as the globalization of the marketplace, economical forces, increase in project complexity, the need to achieve faster results, rapid changes to project scope, new procurement practices, and client sophistication (Alshawi & Ingirige, 2003).

Due to these various internal and external factors, construction industry is investing more in information technology. Recent data on the use of information technology by the contractors show an average 334,241 dollars of IT spending in construction

companies with dedicated (internal or outsourced) IT personnel (CFMA, 2006). Among these, General Contractors lead the industry with 531,528 dollars of spending compared to 279,404 and 241,833 dollars for Heavy/Highway and Specialty Contractors respectively (CFMA, 2006). IT investments on average can reach up to 1,733,861 dollars for companies with annual revenues exceeding 250 million dollars (CFMA, 2006). The same survey reveals that as of 2006, 83 percent of respondent companies employ dedicated IT personnel, 35 percent of which is internal, and 48 percent is outsourced. In 2004, however, the same CFMA survey found out that only 57 percent of construction companies employed dedicated IT personnel, 47 percent of which was internal, and 10 percent was outsourced (CFMA, 2004). This demonstrates a 45 percent increase in the number of companies with dedicated IT personnel in the period of two years.

3.4 BARRIERS TO TECHNOLOGY ADOPTION IN THE CONSTRUCTION INDUSTRY

In construction industry, as in many other industries, IT capabilities are utilized either to perform tasks more efficiently or do otherwise impossible tasks (Allen et al., 2005). Although IT's contribution to the organizations has been highly recognized, there are barriers for successful adoption and diffusion (Becerik, 2006). Williams et al. argue that some of the major barriers perceived by the construction practitioners are lack of industry collaboration, needed training, and the high cost of implementation. In general, however, these barriers can be grouped under technical, behavioral, cost-related, organizational, and legal barriers (Bjork, 2003). These barriers include:

1. hard vs. soft documentation and communication
2. the ownership of information
3. indistinguishable return on investment
4. technological limitations on the construction site

5. financial risks and organizational learning risks
6. organizational inertia and resistance to change
7. intellectual property law and antitrust concerns
8. security, confidentiality and system reliability.

All these individual factors are affecting construction industry's adoption pace and usage levels of these technologies. In order to deepen our understanding of the barriers and their impact, it is important to analyze all these factors separately in their own context.

3.4.1 Hard vs. Soft Documentation and Communication

Traditionally, construction industry has relied on paper-based documentation and communication. As being one of the oldest industries in the world, all the standards of documenting and communicating have been established much before than the introduction of personal computers and the Internet. Especially when we recognize the fact that today's top managers in the construction companies mostly belong to "baby boomer" generation all of whom were introduced to computer and world-wide-web at later stages in their lives it becomes easier to notice the difficulties in transition from hard to soft. It is also reasonable to expect that with the Generation X and Generation Net replacing the Baby Boomers at the upper levels of the career ladder, construction companies' adaptability and eagerness to adopt new technologies will be enhanced. This argument can be supported by the FMI survey (2005) regarding the contractor productivity. As a part of the survey, the age group of the field management and its link to productivity levels are discussed. The average field manager age in the survey was forty-two while the companies that had experienced productivity improvements in the recent years have a noticeably younger field management. The underlying reasons for this fact have been argued by the authors as the inability of the older generation to keep

up with the new trends in the industry as a result challenging the common belief that experienced management in the field is a competitive advantage (FMI, 2005).

In addition, Allen et al. argues that the professional licensing and building laws enforce the usage of paper instead of soft-copies. Professional licensing in the U.S. requires architects and engineers to be held accountable for their work. This accountability is achieved through official stamping of the documents with a valid license number given by each state to the architects and engineers who would like to operate in their state of choice (Allen et al., 2005). In line with this, building regulations also require the submitted drawings to be stamped as prerequisite for building permits (Allen et al., 2005). Allen et al. also highlight the attitudes of professional trade associations such as the American Institute of Architects (AIA), the Associated General Contractors of America (AGC), or National Society of Professional Engineers (NSPE) towards collaborative practices in general. According to the authors, with the aim to solely protect the interests of member parties, these associations are motivated to institutionalize non-collaborative practices. One example is given as the AIA-B141 – Standard Form of Agreement between Owner and Architect, which includes the provision of the contracts are proprietary. This provision by nature restricts collaboration because it does not allow the other parties to view the contract documents (Allen et al., 2005).

3.4.2 The Ownership of Information

Ownership of information is one of the issues that impede the usage of new technologies in the construction projects. By definition, ownership of information describes one's right to use, enjoy, alienate, and exclude others from the use of the same tangible matter (Lipinski and Britz, 2000). Who has the right over the information that kept on the PMCS is an important question has to be answered before any major investment decision. According to Allen et al. (2005), if the project extranet is introduced by the owner, it provides the owner with more supervision over the project and unlimited

access to the project information. However, if it is introduced by the contractor, the contractor perceives the tool as a medium for its project management practices and generally chooses to give limited access to the owner if not at all (Allen et al., 2005).

The same topic also relates to the concept of “public good”. Castle (1999) categorizes PMCS in his definition, project networks, used for project management and collaboration in the construction industry as non-rivalrous public good in which one firm bears the cost of setting up such a system, and the other participant firms in the project benefit from the system at no additional cost. This free-riding of resources by several parties introduces complications for company’s investment decisions. Castle (1999) suggests that the total cost of such systems should be divided among team players. However, this will necessitate a proof of tangible benefits of these systems for the companies involved (Castle, 1999). This expectation motivates the discussion of ROI for Information Technologies.

3.4.3 Indistinguishable Return on Investment (ROI)

As Love and Irani state “the justification of investments in IT is one of the many challenges facing managers in the construction industry today, as there is an ever-increasing demand for organizations to improve their performance and productivity” (Love and Irani, 2001, p.649). The desire to know the exact returns related with IT investments makes business sense. The spending for IT can reach astronomic amounts, which requires detailed calculations and calls for explicit answers. CFMA’s IT Survey predicted 334,241 dollars of IT spending in construction companies in 2006 alone. With such significant spending at stake managers rightly demand the “bottom line benefits of each investment in IT [to] be accurately identified and quantified” (Allen et al., 2005, p.307).

The question of ROI for IT investments is a difficult one to answer, not only because there is limited data but also because ROIs of IT investments are interrelated with other

processes using that technology (Allen et al., 2005). This makes the identification of ROI separately for IT unfeasible (Allen et al., 2005).

3.4.4 Technological Limitations on the Construction Site

Sometimes despite the will to practice more advanced technologies, there are certain technological limitations on the construction job site. Bandwidth is one such example (Becerik, 2006). The bandwidth may limit the size of the documents that can be transferred through the server especially if you consider the fact that many construction documents like drawings, sketches, and pictures all demand a superior bandwidth in order to wire-transfer across team members. Besides bandwidth problems, today there are still some construction companies in the U.S. that are not fully equipped to support technologically-enhanced project management practices. A recent survey done by Williams et al. (2007) among contractors from 152 US companies, found out that 18 percent of the construction companies does not have Internet access on the construction site, and 8 percent does not have computers on site.

Another barrier for the use of web-enabled PMCS in certain projects may involve government projects and government regulations. Some of the government offices in the U.S. do not allow their own personnel to download or install any software other than the information system policy approved (Castle, 1999). These restrictions or limitations certainly harden the collaboration attempts between project team members, which by nature necessitate some flexibility in downloading, editing and sharing of information.

3.4.5 Financial Risk and Organizational Learning Risk

The indistinguishable ROI along with the limited ability to transfer the additional costs associated with IT investments can be identified as the main financial risks the companies have to encumber (Allen et al., 2005). Companies also consider the cost of

hardware and new equipment as well as the training of the staff when considering investing in IT or any other new technology.

Organizational learning risk, on the other hand, can partly be attributed to the learning curve phenomena. This phenomenon, which was first introduced to the world through Mr. Wright's studies on airplanes in 1936, has implications in every industry till this date. Wright (as cited in Yelle, 1979) explained his theory based on his observation of the number of goods produced by individual increases, while the number of hours that a person requires to produce that good steadily decreases over time. Later research also analyzes the impacts of interruptions on the learning curve such as adoption of new technologies. Yelle (1979) suggests that, although the term "learning curve" initially applied mainly to labor learning, it encompasses managerial and organizational learning as well. The learning curve phenomenon can relate to this research as the waiting period in order to obtain meaningful productive results or returns as a result of technological investments. Jersild (as cited in Kavcic et al., 1999) first introduced the concept of "switching cost," a term used for the added time required for the current performance levels to match the previous performance levels when a change in tasks is introduced. This created an opportunity for researchers to assess the time necessary to reorganize certain cognitive behaviors. As expected, there will be a cost associated with this change, and investing in IT can be a very challenging proposition if the benefits of these investments are not clear. However, if the use of IT/extranets/project networks gets more common in the industry and if professionals become more acquainted with these tools, even in the case of project changes, the learning curve will be less steep (Castle, 1999). It should also be emphasized that the "cost of learning" has always been overestimated (Allen et al., 2005). Research shows that the learning curve associated with learning a new technology is shorter than the companies' initial expectations, mainly due to the fact that the skill sets that are required to learn these kinds of technologies already exist in the AEC firms (Allen et al., 2005). We can also find psychological/mental roots in the

tendency to overestimate the costs for technological upgrades such as organizational inertia and resistance for change.

3.4.6 Organizational Inertia and Resistance for Change

Organizations have the tendency to use the methods/knowledge they acquired and practiced in the past when approaching new problems. As a result of this, technological change cannot be adopted spontaneously. It should be injected to the existing structure and in many cases this requires the decisiveness and involvement of top management. Research shows that top managements' involvement in the adoption of IT practices is essential (Byrd & Davidson, 2003). Nikas et al. (2006) found that, in the case of adoption of collaborative technologies, the managements' commitment is recognized and appreciated mainly through the level of the extensiveness of employee training and skill development.

Besides the cognitive factors, there are also psychological factors that affect change in organizations. Employee resistance to change has been cited as the most common problem for change implementation (Bovey & Hede, 2001). People in general tend to resist change (Scott & Jaffe, 1988). Scott and Jaffe (1988) divide the process of change into four major stages: denying, resisting, exploring, and committing. According to this framework, people, depending on the severity of change, first deny the change and try to continue with their regular tasks as if nothing had happened or changed. The decisiveness of management, sometimes with the help of external consultants, moves the company to the next stage, which is called the "resistance phase," according to Scott & Jaffe (1988). In our case, when all the computers of field personnel are equipped with the new web-enabled PMCS, the resistance phase might reveal itself through the resistance or rejection by employees to utilize the system as it should be utilized. The new interface along with new tools and commands can create confusion and reluctance, which at the end may impede the diffusion of the new technology. At this stage the benefits are relatively more obscure, yet the limitations and drawbacks of the PMCS are

more obvious to the field personnel. With some patience and dedication, when this stage passes, the next stage of exploring starts (Scott & Jaffe, 1988). This represents the stage in which the field personnel start to explore the system installed and tries to find ways to effectively use it in their daily operations. This is also the stage where field personnel can more objectively identify the benefits and limitations of that system and make future recommendations. As a result, this stage can provide good opportunities for the managers and/or IT consultants in consultation with the personnel who use the system, to challenge the existing system and come up with improvements based of the field personnel needs. Finally, during the commitment stage, all the new roles and goals are identified, and the ambiguity is minimized leaving it to certainty and confidence (Scott & Jaffe, 1988). This phase can not be considered as the most productive phase in the sense that field personnel once again truly absorb the change and become non-judgmental till the next round of changes are introduced. This theoretical framework of change provides valuable insights to top management on what to expect when change is introduced.

During change people experience self-doubt, anger, depression, anxiety, frustration, fear and uncertainty (Scott & Jaffe, 1988). These kinds of feelings will have a direct impact on the kind of change that a company would like to implement. Ignoring the human side of any change will result with limited if not at all, acceptance levels by the employees. Especially the implementation of technological change requires pre-planned approach in which all the resistance variables of the individuals, groups and organization in general are predicted and understood, and change models for all the interest groups are determined (Davis, 2004).

3.4.7 Intellectual Property Law and Antitrust Concerns

The underlying assumptions of today's intellectual property rights are derived from property ownership, which Locke referred to in 1689 as one of the three basic human rights: right to live, right to freedom, and the right of ownership (Lipinski & Britz,

2000). Lipinski and Britz (2000) also refer to Locke and his explanation of property rights, i.e., every individual has the right to profit from the efforts of their labor, which also extends to intangible property. Intellectual property is defined as intangible property by the authors.

U.S. courts label technology as “goods” instead of “professional services” (Allen et al., 2005). According to this classification, an application service provider (ASP) cannot be considered as a professional services provider; instead it is considered a consumer goods provider. In line with this classification, software companies market consumer goods which restrict their liability to consumers under the Unified Commercial Code (Allen et al., 2005). A related example is given by the authors, describing the Supreme Court Case between M.A. Mortenson Company and Timberline Software Corporation. In this specific case, the software company Timberline, provided the construction company, Mortenson, with a defective estimating software package, which caused the construction company to underbid one of its projects for \$1.9 million (Allen et al., 2005). The disclaimers in the software package, which limited Timberline’s liability as a provider, were used to resolve the case in favor of the software company (Allen et al., 2005).

Antitrust concerns, on the other hand, have been raised over B2B (business-to-business) or P2P (peer-to-peer) applications. Some of the web-enabled/web-based PMCS support e-commerce and e-finance applications. According to Berning (2000), these virtual marketplaces constitute an environment for collusion and price fixing. The author argues that these online applications have the potential to be used as a ground for suppliers signaling price changes, for competitors cooperating to keep costs down, and for bigger firms to exclude smaller players from the market (Berning, 2000). Moreover, the vast amount of data in these systems can be used by companies to track sales and make strategic pricing decisions, on the surface appearing not talking to each other (Berning, 2000).

These kinds of examples challenge today’s laws and raise questions concerning security, confidentiality, and system reliability.

3.4.8 Security, Confidentiality and System Reliability

The safety and confidentiality of data, during and after the completion of a construction project is highly critical. With wide usage of the Internet, it has become more difficult for companies to understand how the confidentiality and security concerns are addressed. There are several concerns that have to be addressed before any IT investment is realized. Loss of data, security breaches by outsiders, unauthorized access by insiders, instant messaging misuse, theft of customer/employee data, and abuse of wireless network can be listed as some of the main concerns regarding the security of the IT systems in general (CSI, 2007). According to 2007 Computer Security Institute's (CSI) Computer Crime and Security Survey, 46 percent of the respondents stated that they had at least one security incident in the last year. Most companies try to protect themselves from security breaches through firewalls, intrusion detection systems, and authentication systems (Ogut, 2006). However, the system misuses and unauthorized access from insiders remain one of the most critical issues. The insider abuse of network systems outpaces virus incidents in 59 percent of the respondent companies, according to the CSI (2007) survey.

Existing web-enabled programs, as well as in-house IT systems all have some type of protection against unauthorized access through passwords and role settings. However, these settings are considered simple and inadequate to fully secure the IT systems of the construction companies, especially when the system is web-accessible (Nitithamyong & Skibniewski, 2004). When online applications are concerned, in addition to the threat of viruses and hacker attacks, the consequences of Internet and system collapses should be taken into serious consideration and companies should be well prepared for them through contingency plans and carefully-reviewed disclaimers (Berning, 2000). As we have seen in the Mortenson and Timberline's case (Allen et al., 2005), the liabilities of the system providers are limited under the current laws and regulations, and the disclaimers are used as the main proof for limited liability.

3.5 PMCS IN THE CONSTRUCTION INDUSTRY

Today in the construction industry, use of Internet-based technologies such as e-mail, database sharing, video conferencing, file transfer protocol sites, project websites, and extranets varies considerably (Becerik, 2006). Electronic mailing has significant implications in every industry. Majority of the construction companies have adopted e-mail for routine daily communication and to share files. In year 2000, the use of e-mail in the construction industry was 90.7 percent and an additional 7 percent of companies had near future plans to obtain e-mail access (Orth, 2000). Like the adoption of many new technologies, most of the concerns that raised questions in the initial stages of e-mail usage have vanished and it has become a common medium for project management and communication. However, e-mailing still embodies the problems pertaining to security and confidentiality, as well as the problems concerning tracking and classification (Becerik, 2006). In addition to technical limitations of e-mailing, social limitations of e-mail should not be disregarded. E-mailing is not the perfect medium for brainstorming, discussing ideas, and reaching compromises (Becerik, 2006). Instant messaging and video conferencing can be of more assistance when near-to-real time communication is needed. In other words, there are business cases in which synchronization is vital for the outcome. In the case of negotiation, for instance, e-mailing may not be as effective as instant messaging or video conferencing.

One of the next contributions for effective project management and collaboration came with the introduction of File Transfer Protocols (FTP). Developed by the Department of Defense in 1969, FTPs provide great opportunities for companies by enabling team members to share sizeable files (Lais, 2000). In addition to transferring big files, one of the other advantageous of FTP is its platform-independent structure, which allows different computers with different operating systems to share the same files (Lais, 2000). Some of the disadvantages, on the other hand, are difficulties and problems in document management, organizing, prioritizing and analyzing data, exact file detection, and security (Becerik, 2006). The security concerns with FTP can be significant when

confidentiality of the files being sent is critical. Even if the FTP site used for file transmission is password-protected, the passwords and usernames are forwarded between the client and the server in a clear text format inviting potential breach (Lais, 2000).

Difficulties in sharing and organizing project information securely and accessing critical information whenever and wherever needed, motivated the adoption of various project management systems. Early systems were all in-house and required bulky IT infrastructure (Bjork, 2003). With the diffusion of the Internet, most of these systems have started using the World Wide Web as their physical network and took on different names some of which are: document management system, project extranet, project web, extranet, and project information management system (Bjork, 2003). Each of these systems can fall in the category of one or more of the following functional models: collaboration technologies, communication technologies, shared information space technology, meeting support technologies, and integrated products (Munkvold, 2003). In this thesis, the systems discussed are all integrated technologies because of the fact that each of them includes project management and collaboration features to various extents. Hence, all of these will all be referred to as PMCS (Project Management and Collaboration Systems).

However, it is important to explain project management and project collaboration systems separately, notwithstanding the fact of two terms being used either interchangeably or mutually to represent one combined management system. With its basic definition, a project collaboration system allows team players to simultaneously interact, communicate, discuss, and share ideas without time and location constraints (Romano et al., 1998). A collaboration system should be equipped with features that support distributed group work such as electronic-data sharing through e-mails, discussion boards, chat windows, and meta-information storage, which allows tracking of edited and shared information (Romano et al., 1998). Given this definition, we can

consider even the simplest form of communication which enables collaboration among team members, such as Microsoft Outlook, a collaboration system. A project management system (PMS), on the other hand, refers to a more comprehensive structure. The majority of these systems include: document management; task management; schedule; and cost control, reporting and resource management modules in one interface (Nitithamyong & Skibniewski, 2004). PMS may, and most likely will, include a collaboration module. Majority of the PMCS allow basic collaboration among team members such as e-mailing and team-calendars. Hence, the PMCS used today are mainly integrated products, which accommodate both the project management and collaboration functions at the same time.

The PMCS can operate either through a client/server based system (Intranet) or through an Application Service Provider (ASP, Extranet) (Phair, 2007). Client-based systems or intranets are private networks, in many cases with access to World Wide Web (Bidgoli, 1999). However, they are separated from the Internet by one or more firewalls (Bidgoli, 1999), and are not intended to be used outside that organization (Jianming et al., 1999). This is the main reason why these types of systems are considered to be more suitable in projects where the need for sharing information across multiple organizations, teams, and disciplines is limited (Phair, 2007). ASP-based systems (extranets), on the other hand, meet the needs of projects where there is a high demand for mobility and fragmentation in disciplines, locations and teams (Phair, 2007) since they extend the intranet system outside that organization through a certain inter-media (ASP) (Jianming et al., 1999). As a result, extranets carry the properties of both intranet and the Internet (Jianming et al., 1999).

The goal to translate an internal standard project management system into an external, Internet-based system, which securely allows multi-user access with dispersed locations, resulted with the concept of Web-based and Web-enabled Project Management and Collaboration System (PMCS) (Nitithamyong & Skibniewski, 2004). In other words,

web-enabled and web-based PMCS provides a centralized “all-in-one” solution both to project management and collaboration needs of dispersed team members. A web-enabled application differs from a web-based application in a major way. As Becerik, (2006) asserts, “Unlike a web-based application, a web enabled application is not based on the HTML language, but instead it is a special software application that is distributed across the Internet much like standard network programs that can be accessed over a Local Area Network (LAN)” (p. 47). Figure 3 illustrates how a web-based PMCS functions (Nitithamyong & Skibniewski, 2004).

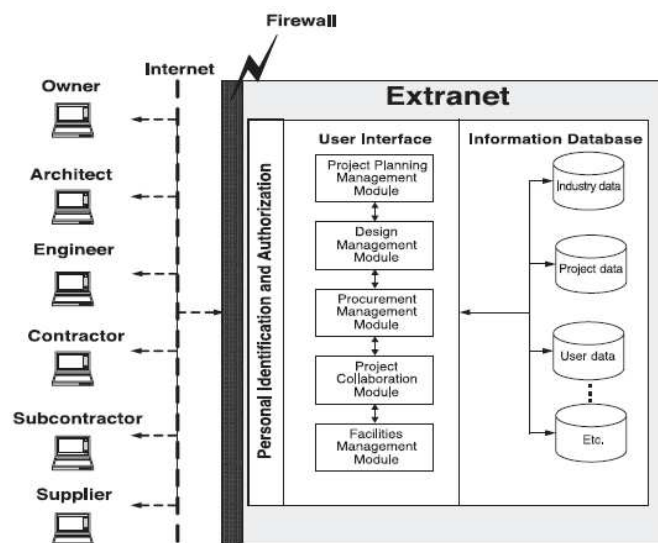


Figure 3. Representation of web-based PMCS functionality (Nitithamyong & Skibniewski, 2004)

As Figure 3 illustrates, web-based PMCS system works through an extranet, based on pre-determined roles and authorizations (Nitithamyong & Skibniewski, 2004). As Nitithamyong & Skibniewski (2004) affirm, “project information is stored on the server and a standard Web browser is used as a gateway to exchange this information, eliminating geographic and boundary hardware platform differences” (p. 492). A firewall acts as a protective shield controlling access to the network, as well as protecting the information flow-out from the network (Intel Glossary). However, even

though firewalls provide acceptable security levels for most companies, a better way for enhancing security is to install VPNs (Virtual Private Networks) to extranets (Jianming et al., 1999). VPNs encapsulate the confidential information into IP packages, and transmit these encrypted packages first to VPN's gateways where the decoding is done and forwarded to the destination host (Jianming et al., 1999). In other words, VPNs secure the network through encryption and authentication of the data being transmitted. In addition to being able to build a customized in-house PMCS, companies may prefer to purchase commercial web-enabled software and install it on the company's internal server (Nitithamyong & Skibniewski, 2004). Examples include but are not limited to MS Project, P3/Suretrak, and Prolog. Alternatively, companies can rent/lease a project management system from ASP for a certain fee (Nitithamyong & Skibniewski, 2004). Examples include but are not limited to Buzzsaw, Constructware, ProjectTalk, PrimeContract, Viecon, BuildOnline, and e-Builder. This option is receiving more attention from the construction industry due to its low initial investment and maintenance costs, and its flexibility to technological updates (Nitithamyong & Skibniewski, 2004). Nitithamyong and Skibniewski (2004) further sub-group web-based project management systems into three categories: (a) Project Collaboration Network (PCN), (b) Project Information Portal (PIP), and (c) Project Procurement Exchange (PPE). PCNs aim to facilitate construction projects through sharing of important documents and communication with its enhanced security and audit capabilities (Nitithamyong & Skibniewski, 2004). PIPs can be considered as information pools where the construction practitioners can find construction related data such as economic trends, material prices, and product information (Nitithamyong & Skibniewski, 2004). PPEs support e-business applications such as electronic bidding and procurement, and requests for price and quotes (Nitithamyong & Skibniewski, 2004).

3.6 BENEFITS OF WEB-BASED AND WEB-ENABLED PMCS

Construction project teams have to manage substantial amounts of information and communication on a daily basis, along with a record of what has been promised and delivered by team members. The necessity to keep a track of these transactions and correspondences for liability purposes, make these systems invaluable. Moreover, web-enabled or web-based PMCS offer many benefits that are uniquely attributable to these systems such as accessibility from anywhere and anytime while providing high level of accountability. In one of the surveys done with 21 selected AEC companies (Nitithamyong & Skibniewski, 2006), the top five benefits associated with these systems, according to the rank of importance, are the following:

- enhanced coordination among team members,
- easy document transfer and handing,
- reduced bottlenecks in communications,
- reduced number of claims, and
- better organized and updated project records.

Another survey carried out with 152 US Construction companies ranked the following perceived benefits of Web-enabled PMCS, in the order of importance, as (Williams et al., 2007):

- receive design approvals automatically,
- provide with visual “as-built” documentation,
- maintain records of correspondences,
- send and receive design drawings electronically, and
- real time information of site, materials, trucks, etc.

Consequently, the benefits related to the adoption of PMCS can be generalized as accessibility and instant communication, improved project efficacy and interoperability, paperless businesses, increased accountability and liability, faster and better decision making, more standardization, and enhanced strategic competitiveness.

Table 1 summarizes common features of some of the commonly used PMCS in the construction industry. Microsoft Groove system is added to the original table in order to provide a full comparison amongst these systems.

In Table 1 when we compare the three commonly used systems in the construction industry Constructware, Buzzsaw, and Project Talk; we can identify seven features that are common (a) document management, (b) project workflow, (c) project directory, (d) central logs and revision control, (e) threaded discussion, (f) file conversion, (g) messaging outside the system, and (h) archiving. Buzzsaw does not accommodate schedule and calendar, website customization, offline access, wireless integration and information service functions.

Constructware does not accommodate conferencing and white boarding, project camera, printing service, website customization, and information service (Table 1). ProjectTalk, on the other hand, does not provide printing service, website customization, wireless integration, and information service. There is no single system which spans all the common features that are in these tables. Microsoft Groove provides functionality in all of the listed features through built-in Groove tools or integration with other Microsoft Office software packages. Some of the functions such as wireless integration and printing are common features in any Microsoft operation system and Groove package offers seamless integration with those features.

Table 1.**Features of Selected PMCS (adapted from Nitithamyong & Skibniewski, 2004)**

		COMMON FEATURES																
PRODUCT		Document Management	Project Workflow	Project Directory	Central Logs and Revision Control	Advanced Searching	Conferencing and White Boarding	Threaded Discussions	Schedule and Calendar	Project Camera	File Conversion	Printing Service	Website Customization	Offline Access	Messaging Outside the System	Wireless Integration	Archiving Project Information	
(Adapted from Nitithamyong and Skibniewski 2004)	Buzzsaw	x	x	x	x	x	x	x		x	x	x			x		x	
	Citadon	x	x	x	x	x	x	x	x		x		x	x	x		x	
	Constructw@re	x	x	x	x	x		x	x		x			x	x	x	x	
	e-Builder	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
	Project Talk	x	x	x	x	x	x	x	x	x	x			x	x		x	
	BIW Technologies	x	x	x	x	x	x	x	x	x	x		x	x	x		x	
	IronSpire JobSite	x	x	x	x	x		x	x	x	x			x	x	x	x	
	BricNets	x	x	x	x	x		x	x		x		x				x	
	HomeSphere	x	x	x	x	x		x		x	x			x				x
	CausewaySolutions	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
	CX	x	x	x	x	x		x			x	x		x	x	x	x	x
Microsoft Groove		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

The features listed in Table 1 do not provide insight about the programs' intangible benefits such as functionality, ease-of-use and ease-of-learning. Research on the usability of project management and collaboration systems highlights many user problems.

3.7 LIMITATIONS OF CURRENT WEB-BASED AND WEB-ENABLED PMCS

There is strong evidence that PMCS is helping the industry to manage construction projects more effectively by contributing to the collaboration practices of the construction industry. Web-enabled or web-based PMCS serve as a common platform where all the project team members, regardless of their geographical locations, can access and contribute to project related information. However, to achieve the intended results from a PMCS, the system should be properly implemented throughout the organization (Hjelt & Bjork, 2007). Current literature shows that there are significant adoption and diffusion issues with the systems available on the market (Becerik 2006; Bjork, 2003). These issues can directly affect the rate of adoption in a setting where the system is not forced by the top management, or they can affect the user satisfaction rates in a mandated setting (Hjelt & Bjork, 2007). Either mandated or not, both of the scenarios end up crippling the web-enabled or web-based PMCS' effectiveness and potential (Hjelt & Bjork, 2007).

Hjelt and Bjork (2007) in their article "End-user attitudes toward EDM use in construction project work: Case study" try to identify the individual attitudes towards EDM, electronic data management, which is a major part of any web-enabled PMCS. They surveyed and interviewed 334 users from a big-scale, approximately \$700 million, construction project. During construction of the project, the PMCS in use hosted 17,000 documents most of which were CAD drawings in AutoCAD format (.dwg), plot files in (.plt) format, Microsoft Word documents (.doc), as well as files in Adobe PDF and Microsoft Excel (.xls) formats. The results of the survey revealed interesting results for the industry. Major portion of the survey participants stated that they were not initially skeptical about the benefits of these systems. Only 10 percent stated some kind of skepticism. This is important because when there are positive motivations to learn something, in other words when there is a willingness to use PMCS in daily operations adoption rates will be positively influenced by these attitudes (Castle, 1999). In addition,

Hjelt and Bjork (2007) research highlight three major limitations hence, improvement areas for PMCS used in the construction industry:

- **Support issues** such as lack of training or inadequate training. Hjelt and Bjork's (2007) research shows that the participants who received limited or no training rate the ease-of-use and ease-of-learning features of the system poorly. In the author's specific case, training was provided only at the beginning. The ones who joined the project team later would be assumed to learn the system from other colleagues. Another finding of the research is that, self-learning of the system is not time-effective and can only be an option only for people with good computer skills.
- **System technical shortcomings** such as the user interface issues and system compatibility, overall speed and reliability.
- **Information quality and reliability** such as folder structure and confidence in the information being up to date. Particularly users' confidence of finding the most up-to-date information on the site stated as low as 25 percent. The complexity of the system and how the folders are structured also play a major role in deteriorating the confidence of the PMCS users.

Another important contribution in identifying the issues regarding the implementation of PMCS came with Becerik's (2006) research on the value of PMCS for AEC industries. The author conducted an extensive data collection through interviews, user surveys, case studies and aggregate data analysis. User surveys constituted of 216 respondents, and the aggregate data came from the research sponsors' databases such as Constructware, Meridian Systems, and E-Build which provided very specifics of client project information. The majority of the AEC professionals responded to this survey stated that they are not comfortable in using web-based PMCS (Becerik, 2006). Figure 4 compares industry professionals' evaluations of their own comfort levels relative to basic

computing such as MS Windows, or any new computer technology other than web-based PMCS technology.

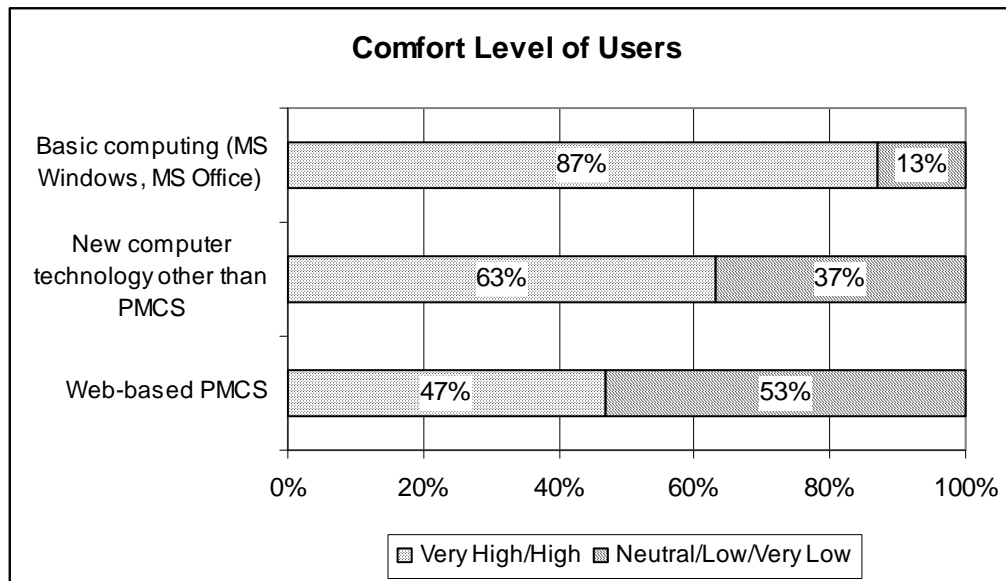


Figure 4. Practitioners' comfort level in using different applications (adapted from Becerik, 2006)

With Figure 4, Becerik (2006) also catches the readers' attention to respondents' comfort levels with any new technology as being higher than their comfort level with a web-based PMCS. In line with these findings, Becerik (2006) highlights the improvement areas of these systems as the need for better compatibility with different applications as well as the need for additional training and user-friendly interface. The extensive use of these technologies and the rate of technology adoption can be achieved if the below selected criteria are considered during system design (Becerik, 2006):

- Robustness, continuity and interoperability: One system solution for all the needs of the project
- Flexibility and customizability: The flexibility to modify different modules in line with the project needs and requirements

- Intelligence: tools that can produce dynamic and rich information, and tools that make sense for construction processes
- Ease-of-use: tools that are easy to learn and use
- Integration: Integration with other applications and hardware

Other research on end-user evaluation of PMCS highlighted issues regarding the suitability of the system for on site use (Mohamed & Stewart, 2003). In one of the case studies conducted by Mohamed & Stewart (2003) on a large-scale construction project with 42 project participants, demonstrated that 44 percent of the construction practitioners did not find PMCS suitable enough for on site use. Although the specific PMCS used in this case study is not mentioned, the survey highlights *mobility limitations* of certain PMCS. Another survey carried out by the same authors on 82 construction professionals from different construction and project management organizations also revealed average scores for the user friendliness of application and tools on PMCS (Mohamed & Stewart, 2003)

Ease of use of PMCS is particularly important because it has a major influence on the effective adoption and usage of the system. In a recent survey, contractors named the most important factor that influences the performance of PMCS as the “ease of use” of the system (Nitithamyong & Skibniewski, 2006). The other significant factors listed according to the order of importance were data quality and reliability, system reliability, internet access availability and team attitudes toward PMCS (Nitithamyong & Skibniewski, 2006). The fast changing work environment of the construction industry leaves little time for professionals to learn and implement new technologies (Dossick & Sakagami, 2008). The goal should be to make these systems easy to learn and easy to use in order to meet the construction professionals expectations for fast and easy project management and collaboration solutions (Dossick & Sakagami, 2008).

From a technical viewpoint, research argues that current PMCS also have several technical weakness and limitations which have to be addressed (Augenbroe et al. 2002). Issues such as, systems' top-to-down enforced mechanic structure which does not allow organic, and spontaneous alteration of the system by the sub-teams based on their needs is stated by the authors (Augenbroe et al., 2002). The authors' viewpoint relates to the *customizability* issue of the existing PMCS in the construction industry. Customizability can be two-folded: customizability to persons and customizability to projects (Chan & Leung, 2004). Every construction project is uniquely different, and the team dynamics and responsibilities even for repetitive projects differ from one another. In addition to pre-defined project teams, many sub-teams will emerge along the way, which might also benefit from tailoring of the existing system inline with the new demands of the project. Another point made by the authors, is the limitations of existing PMCS for *personalized viewing*, which complicates team members accession to relevant information (Augenbroe et al., 2002). Current PMCS should enhance its filtering functions to direct the user to targeted project information with desired level of detail (Augenbroe et al., 2002). It is a common knowledge that construction projects produce thousands of documents and eventually it may reach to a point that finding the exact data needed can be burdensome. In that case, having a manageable PMCS structure in place can facilitate the user in a friendlier and personalized way hence, improving the decision making processes. Many documents are related to each other in the current document management structure of today's construction projects (Augenbroe et al., 2002). Providing a link between those documents can improve the users' ability too see the whole picture, hence interpret the right meaning out of those documents (Augenbroe et al., 2002). An implication of this can be found in the RFI document management structure. Many RFIs created during the construction project are inter-related. A PMCS which allows linking related RFIs to one another can minimize the time and effort needed to navigate the whole system trying to find the other related RFIs.

Consequently, it can be argued that web-enabled and web-based PMCS currently available in the market are already offering a lot of functionalities to construction companies, and helping teams to improve their communication, collaboration and project management capabilities. However, as Lapple (2005) asserts it “theoretically, there are no limits to the functionality. The limitation is more likely the abilities of the users to operate the software functions.” (p. 20). Having said this, Groove Network has the potential to provide a much easier to learn and easier to use project management and collaboration environment for practitioners and a better functionality than other major PMCS provide.

3.8 MICROSOFT GROOVE NETWORK

In the related literature, we do not see any research that focuses on the adoption of Microsoft Groove and its adaptability to the construction industry as project management and collaboration software. Due to non-availability of previous research on the topic, this section aims to introduce Microsoft Office Groove based on product information, press releases, and case studies provided by the developers. The technical and functional properties of Groove will be analyzed in depth in the subsequent chapter. This section aims to provide a general overview about the history of Microsoft Groove as well as some non-construction industry applications of the system.

Groove Networks, founded in 1997 by an ex-IBM development team led by Ray Ozzie, was acquired by Microsoft in 2005, according to a Microsoft press release dated March 10, 2005. Microsoft started investing in the company before the acquisition, because of Groove’s Windows compatible system and its complementary characteristics to Microsoft Office System technologies such as Windows Share Point services (Microsoft, 2005).

Although, related literature does not indicate any research regarding the adoption of Groove technologies in the construction industry, there are examples of other industry's successful implementation of Groove. One such example is the use of Microsoft Groove by Louisiana State University's Emergency Operations Center (EOC) as the only collaboration and coordination software, in the aftermath of Hurricane Katrina (Morello, 2006). One of the main lessons learned after this tragic event, the need for a centralized command and control system during emergencies, led officials to establish the EOC (Morello, 2006). Another important lesson was that after a big and wide-spread emergency situation the need to collect and share information as fast as possible is extremely critical (Morello, 2006). But in case of a disaster such as Katrina, where most of the power and energy lines are destroyed and the internet connectivity is none or limited, using any kind of system becomes a major challenge (Morello, 2006). Besides, in cases like this, many different agencies (i.e. fire department, police department, municipals etc.) have to be involved in the recovery efforts. Since the computer systems of these official units usually vary, the compatibility of these systems becomes a major issue (Morello, 2006). EOC, after a thorough review of the available systems, decided to adopt Microsoft Groove as their collaboration software mainly because Groove system meets the critical needs of easy access, ease of use, and compatibility (Morello, 2006). When the internet connection does not exist, agencies can still access their current workspaces and update information. When the internet connection even with a limited bandwidth is established, the synchronization of all the agency's workspaces can be realized. Groove's easy to use layout and features make it easy for government agencies to practically use the system and not spend too much time on figuring out how to use it during a case of emergency, where time is extremely valuable.

In another case study, the Groove system is used as a management and collaboration tool by Steelcase Corporation which reported to provide 10 percent saving in their project costs (Microsoft, 2006a). Steelcase, a global office furniture company, had several business challenges which have led them to adopt Groove. Increased penetration and

sales volume in international markets created a need for virtual teams composed of members from different business disciplines and locations. As a result, the need for collaboration software with the potential to create a common and neutral platform to bring people together became apparent. With the successful adoption of Groove, Steelcase reportedly not only reduced costs due to less business traveling, teleconferencing, and increased productivity but also managed to create more cohesive and frequent interactions among project team members (Microsoft, 2006a).

4 RESEARCH AND DEVELOPMENT METHODOLOGY

This study focuses on demonstrating Microsoft Office Groove as an alternative tool for the project management and collaboration. The goal is to illustrate the potential applications of this software for construction projects and to propose it as an alternative web-enabled tool. To achieve this goal following four-step methodology is followed:

- Review built-in and downloadable Groove system tools
- Modify selected Groove tools to create designated modules with customized construction templates
- Define a workspace template to gather project input and distribute progress information to project team members (owner, CM, subcontractor, designer and the supplier)
- Illustrate the workspace template structure using a sample construction project

The four-step methodology requires a clear definition of the Groove system structure and available tools. As a part of this chapter, the system structure and individual tools are described to establish the framework for the development methodology.

4.1 GROOVE SYSTEM STRUCTURE

Microsoft Office Groove is a fast and dynamic collaboration tool which supports online and offline collaboration and communication between geographically-dispersed team players through collaborative workspaces. A workspace is a virtual environment where the various program tools are accessed. Anyone who has Groove loaded on his or her computer can create a workspace and invite others to join that workspace. Invitees who accept the invitation can create a copy of that workspace and collaborate with others to

the extent they are allowed. This enables parties to work and share information securely and in real time. In addition, parties can work on the same workspace offline, make changes, create and edit documents. Groove synchronizes each team player's workspace when they connect to the internet. Figure 5 illustrates the Groove system structure and the connection options between the team players (Microsoft, 2006b)

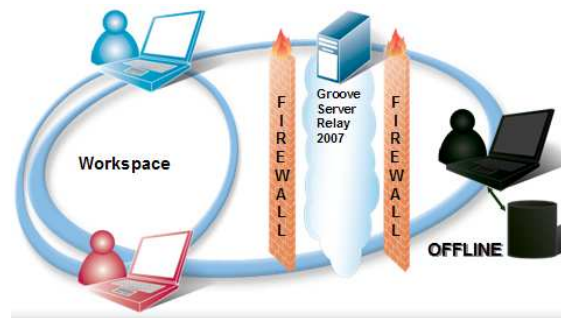


Figure 5. Microsoft Groove workspace connection options (Microsoft, 2006b)

As illustrated in Figure 5, Groove manages synchronization through a simple and decentralized architecture. Groove stores the workspaces on personal computers of the team members and does not require a central server. When a change is made either online or offline, the synchronization immediately takes place once the editor and the receivers connect to the Internet. It is also possible to use a simple server directory as the relay point for all users. Staying synchronized is critical for the Construction Industry. The required amount of information exchange in construction projects and the need to be quick in responding to changes in the current project conditions, validate the necessity to stay synchronized most of the time, even from remote locations.

From a user point of view, there are five main components in Microsoft Office Groove system structure: (1) launch-bar, (2) workspace, (3) presence and communication, (4) alerts and (5) tools (Chou, 2006).

4.1.1 Launch Bar

The launch bar is the initial window, where new workspaces for new projects are created. It is the initial view that pops up when the software is activated. With Groove, it is possible to create multiple workspaces for different groups, projects or for other purposes.

Groove launch bar groups workspaces under “active”, “unread”, or “read” categories. An active workspace represents the workspace that is in use at that moment of time. If changes were made on the workspace when the user was offline, and the user had not reviewed the changes yet, the workspace is placed under the unread category. This, on its own, is a simple indicator that some changes are made. Once these changes are reviewed by the user, the workspace is re-grouped under “read” category until a new change or update is introduced to a particular workspace. Figure 6 shows a sample Groove toolbar view with one sample workspace that is currently active.

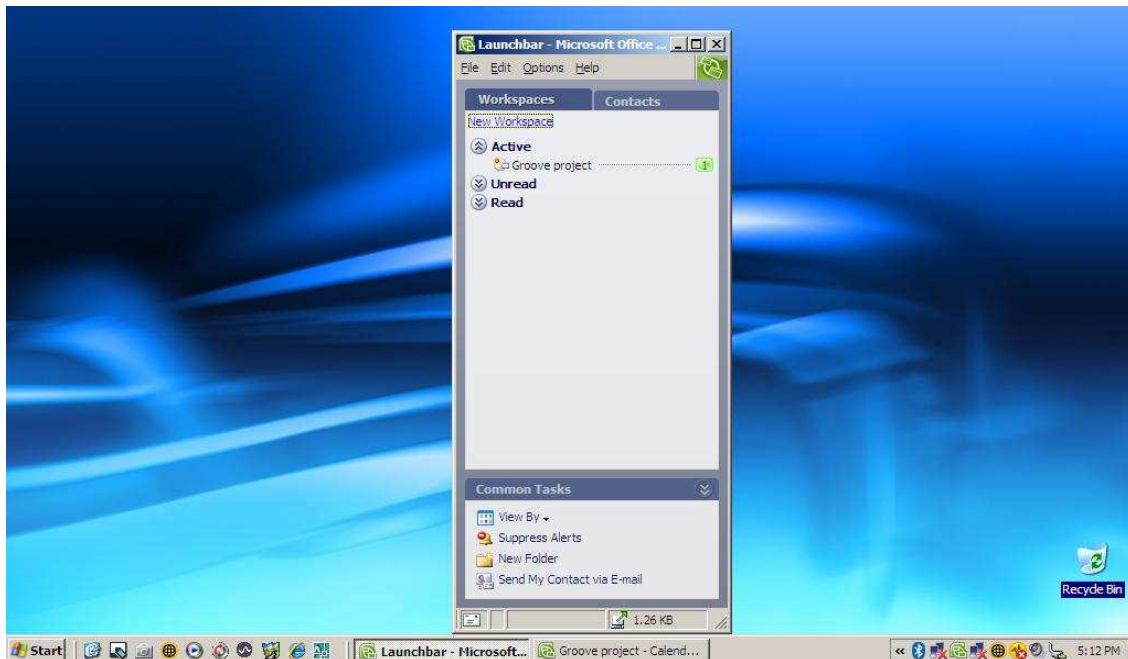


Figure 6. Groove launch bar view

Launch bar has two task panes: workspaces and contacts (Microsoft, 2007). Launch bars' workspaces pane display all the workspaces users have access to. Launch bar's contacts pane display the names of team members that have access to the workspaces with different levels of permissions.

4.1.2 Workspace

Workspace is a virtual collaborative platform facilitating project management activities such as sharing, changing, and updating project files, as well as collaboration and communication activities such as chatting, discussing, drawing, and coordinating meetings. Multiple workspaces can be created as needed. Furthermore, based on the needs of the project one of the following types of workspaces can be selected (Microsoft, 2007):

- Standard workspace: is the simplest form of a workspace, including only the files tool and discussion tool. However, additional tools can be integrated based on the needs of the project.
- File sharing workspace: is used when there is a need to synchronize selected Microsoft Windows operating system file folders and its contents with other project team members.
- Template workspace: allows the user to choose one from Microsoft's pre-customized templates designed specifically for certain industries and project types. Currently, there is not a pre-customized, ready-to-use template created by Microsoft for construction industry and construction projects

Sharing of the workspaces is done through inviting other team members with certain assigned roles. Project Manager or some other project member with enough level of authority can initiate the workspace with the manager role, and invite other team members by assigning them one of the three possible roles. The predefined roles in Groove are: manager, participant and guest. The permission settings of each role can

also be manipulated based on the needs of the project. Figure 7 is adapted from Chou (2006) to illustrate the permit levels of each role.



Figure 7. Role's access levels in Microsoft Office Groove (adapted from Chou, 2006)

In Figure 7, if the assigned role is manager, then the user generally has all the technically possible permissions on the system, such as inviting/uninviting members, adding/deleting new tools, and editing, viewing, deleting documents. Participants can usually invite new members and add new tools as well as edit certain documents. Guests, on the other hand, have the most limited authority on the workspace, generally only allowed to view read-only documents.

The process of inviting team members to project workspaces is very simple. New members are invited through the “options” menu on the toolbar and then selecting “invite to workspace”. Once the invitation is sent and the invitee connects to the Internet, a message and a copy of the workspace is delivered. If the invitee accepts the invitation, the workspace is copied to that user's personal computer. The only requirement for copying the workspace is having Groove loaded on the receiver's computer.

4.1.3 Presence and Communication

Presence and communication functions of Groove system allow users to see which other users are currently active on the system and which tools they are working on, as well as supporting real time communication between team members. There are two main built-in, real-time communication options on Groove workspaces: chat option and messaging option (Microsoft, 2007). Chat window supports instant communication between team members in both text and audio format. The receiver of the text message does not have to be online to receive the message but for audio messages the presence of the receiver on the workspace is required (Microsoft, 2007). By using Groove audio function on the chat box, the user can broadcast an audio message to rest of the online users. Messaging function, on the other hand, is designed mainly to send messages which concern certain team members (Microsoft, 2007).

Groove system can uniquely integrate office messenger systems to its workspace hence, enhances instant communication features by adding the messenger webcam, phone call and document sharing capabilities to the system.

4.1.4 Alerts

Alerts are designed to proactively inform the user about changes on the workspace (Microsoft, 2007). These alerts may pop up in text format or make an audio warning when one or more of the following changes on the workspace occur (Microsoft, 2007): (a) any new information added on the workspace, (b) any new information added in a particular tool, (c) changes made on a specific file or folder, (d) other users enter the system, (e) new messages and invitations received, and (f) the status of sent messages and invitations change.

4.1.5 Tools

Tools represent the type of work the project team is performing (Microsoft, 2007). Groove provides flexible and customizable tool options where project teams can create a combination of them based on the project needs. By using these tools various templates

such as RFI forms or RFP forms can be created and managed. In this thesis, some of these tools are utilized as parent tools and customized according to the construction industry standards. These tools are analyzed in detail in the following section.

4.2 GROOVE TOOLS

Groove system by default accommodates various tools. These tools can be used as they are or can be modified according to the needs of the projects. The majority of these tools with the exception of the “Welcome Page” and “Proposal Tracker” are part of the existing Groove system structure. The “Welcome Page” and “Proposal Tracker” tools are all ad hoc tools which can be downloaded from Microsoft website. It is also possible to download even more variety of ready-to-use tools from the same web-site.

4.2.1 *Welcome Page Tool*

Welcome Page Tool provides team members with a user-created reference guide for the project. The system and its tools may not be familiar to all team members, especially at the beginning of a project. As a result, providing information about the tools, processes and procedures regarding the utilization of this collaboration platform, would be very helpful when initiating a new project. The Welcome Page tool is not a standard part of the Groove system and has to be downloaded from Microsoft Online. There is not a pre-existing form or template that can be modified in this tool. It is solely up to users to create this page.

4.2.2 *Calendar Tool*

Calendar tool is used to mark project deadlines, milestones, holidays, meetings and important events. Calendar allows the users to mark any specific date and time as new appointment, and can display the appointments with four different display options (today, day, week, and month)

4.2.3 Meeting Tool

Meeting tool organizes and helps to track project meetings. In addition to marking and alerting the users about the meeting's date and time, it also displays information about the attendees and their roles in the meeting, such as the chairman or the minutes-taker. Moreover, it provides the platform to write, store and share the meeting agenda and minutes with team members.

4.2.4 Discussion Tool

This tool provides an organized, but at the same time flexible discussion platform in which all the team members, based on their roles, can either create posts or respond to posts created by other team members.

4.2.5 Files Tool

Files tool provide a tree-diagram like layout to organize unstructured documents on the workspace. Documents created with formats like “.XLS”, “.DOC”, “.PPTs”, are considered unstructured documents hence, can be accessed through this tool. However, many of these documents may well be replaced with structured documents created using “Groove Forms”, “Issue Tracker” or “Proposal Tracker” tools which are all explained in the subsequent sections. The processes followed in this module are no different than any folder/file adding processes of any Microsoft Office product

4.2.6 Issue Tracking Tool

Issue tracking tool provides a single platform to track issues. Issue tracking is very important in construction projects because if not properly tracked, issues may expose the project to new risks. This tool lists issues in time order and assigns a tracking number to each issue. In addition to giving team members the platform to describe the issue in narrative, the tool also provides specific information regarding the issue status, date the issue is created and the deadline for it to be closed, as well as the severity (high, medium or low) of the issue. Since the severity is an indicator of the issues' risk impact on the project, more caution can be given to the ones with the highest severity. The risk

assumptions that are created during project planning phase can be a direct input for this tool.

4.2.7 Proposal Tracker Tool

Proposal Tracker manages and organizes the entire RFP/RFQ processes. This tool helps to create and/or modify RFP/RFQs in one simple template. This tool is not a standard part of the Groove system. It is an ad hoc tool that can be downloaded from Microsoft website. Proposal Tracker provides two built-in, interrelated user forms: one for defining the opportunity and the other for assigning tasks. Based on the needs of the project, these two forms can be either modified or re-created.

4.2.8 Forms Tool

If the existing built-in tools are not meeting the project teams' specific needs, a new form with a module to manage these forms can be created using this tool. Forms tool does not accommodate pre-existing views or layouts. As a result, it is solely up to users to determine the information needed on the form as well as its layout. Since there are no built-in forms in this tool, users have to create the forms either selecting the information to be displayed on the form from a list of fields provided on the initial view (i.e. author, date, modified by) or by adding more fields in order to integrate custom information.

4.2.9 SharePoint Files Tool

SharePoint Files Tool provides an expanded opportunity to share project documents on the Groove workspaces with the rest of the organization through the use of SharePoint Server libraries. Sharepoint Server provides a central storage and can easily be used in conjunction with Microsoft Groove system. Groove when used on its own does not require a central server.

4.2.10 Sketchpad Tool

Sketchpad tool adds to the functionality of Groove structure, by providing easy-to-use sketching options for project team members. Sketchpad can be used to describe and discuss issues visually and interactively. This tool facilitates team members' manually sketching or it also allows users to insert pictures in .jpg format files and mark on them. Both the sketching and markings on picture files can be seen and followed real-time by other users.

It is important to note that all the above-mentioned tools can be customized and adapted to the needs of the project and the industry it is in. In the following chapters, some of these tools are selected to be used as designated modules of a sample construction project and customized based on the Construction Industry's project management and collaboration common practices.

5 TEMPLATE WORKSPACE DEVELOPMENT

In this chapter, the development of a template workspace is described for a typical construction project. Although, every construction project is unique and may require different set of features, it is possible to customize Groove's built-in tools and create designated modules to meet the needs and requirements of different projects. Figure 8 illustrates the framework for the template workspace for a typical construction project.

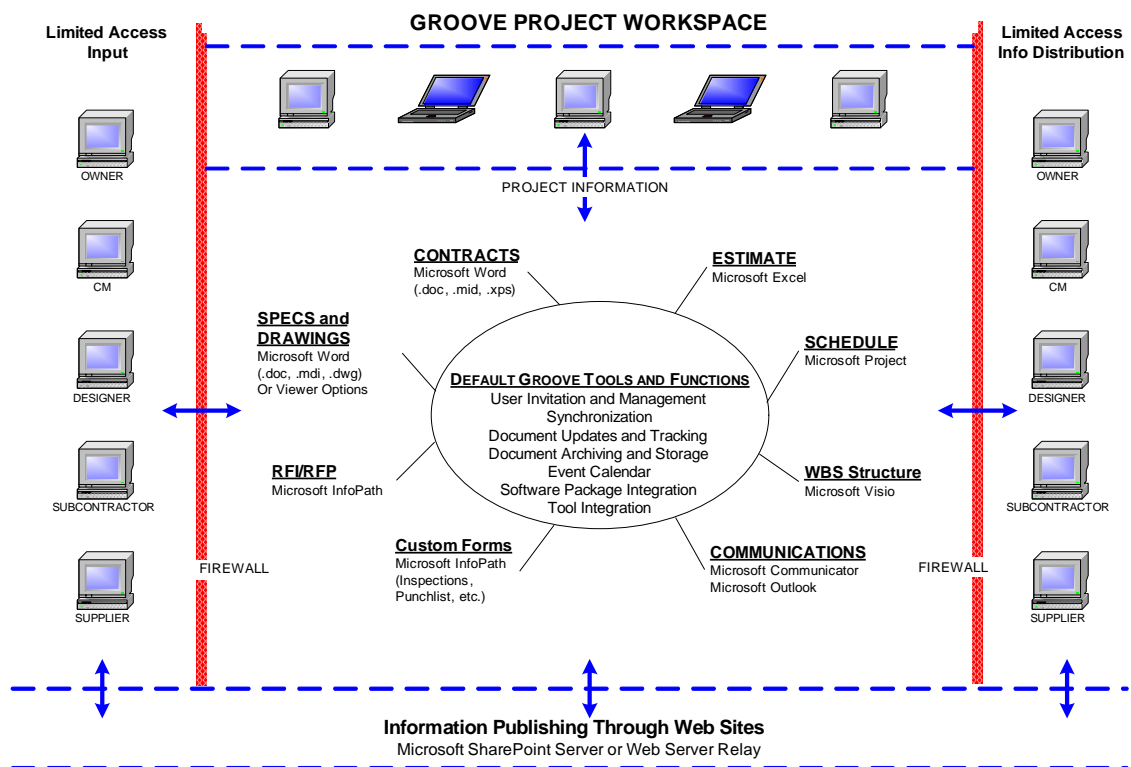


Figure 8. Microsoft Groove workspace structure for a typical construction project

As illustrated in Figure 8, the Groove customized workspace is structured around the built-in functions of the software. Construction project management practices mandate the use of certain documents throughout the project life cycle, some of which are

contracts, estimates, schedules, RFIs, RFPs, specifications and drawings. Collaboration among project participants is a vital element of any system structure. To address these needs, the following organizational steps were implemented.

- Implement built-in Groove tools as designated modules without modifications (i.e. calendar module, meeting and sketchpad modules)
- Adopt and implement selected built-in Groove tools as designated modules with major modifications (i.e. RFP module and RFI module).
- Implement new designated modules using built-in Groove tools (i.e. Change Order and Change Directive module)

Several built-in tools were selected as designated modules for this template workspace. This selection is done considering the common practices and needs of typical construction projects. Groove tools selected as designated modules are:

1. Calendar tool
2. Meetings tool
3. Files tool
4. Forms tool
5. Issue tracker
6. Proposal tracker
7. Sketchpad tool

5.1 CALENDAR TOOL

As Figure 9 illustrates, the default Calendar tool helps to track important events and milestones put in by the project team. Its default view shows monthly display, though daily and weekly display options are possible too. This tool is used as the project calendar module for the sample project without modifications.

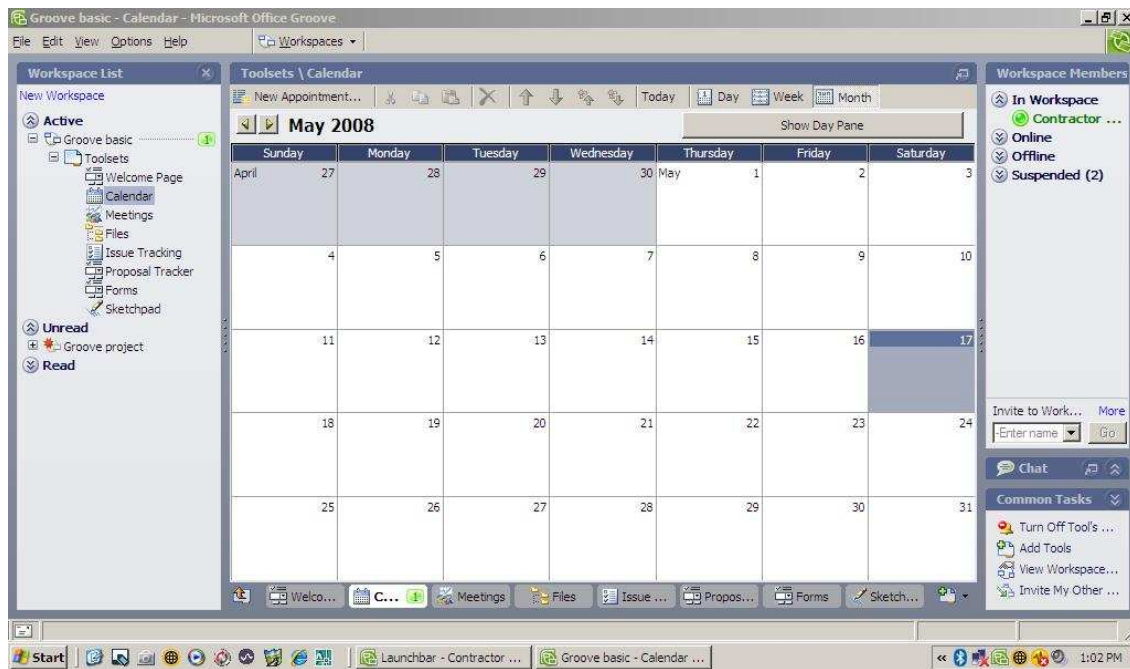


Figure 9. Groove calendar tool default-view

5.2 MEETING TOOL

The Meeting tool is designed to coordinate meetings for project team members. As shown in Figure 10, the default view has five panes named as “Profile”, “Attendees”, “Agenda”, “Minutes” and “Actions” respectively. Profile pane is the initial view when a new meeting is created on the system. Meeting attendees are identified, certain roles are assigned and if needed the agenda as well as the meeting minutes are created using the same tool.

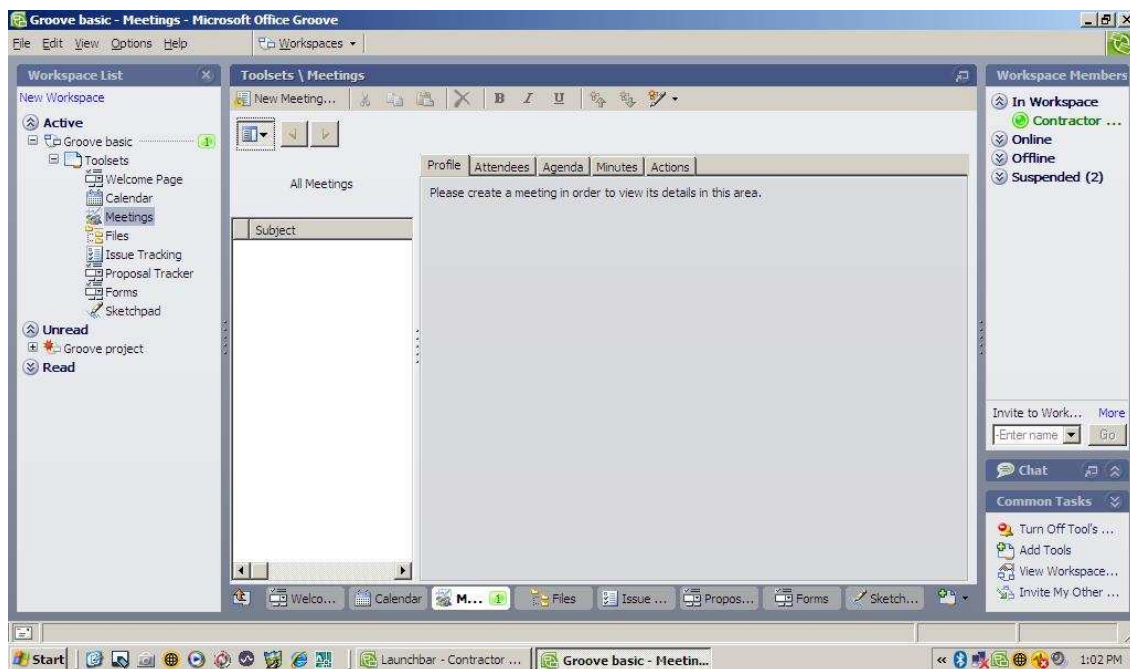


Figure 10. Groove meetings tool default-view

The meeting tool is adopted as a meeting module for the sample construction project without any modifications. In the subsequent section, sample project meetings are marked and meeting information is entered to demonstrate the modules' functionalities for the construction projects.

5.3 FILES TOOL

Files tool is a built-in tool designed for organizing, storing and sharing unstructured documents such as contracts, drawings, specifications, and schedules with varying file extensions such as DOC, XLS, PDF, and CAD. It is possible to create as many folders and upload as many files as needed. Figure 11 shows the tree-diagram like folder structure of the tool which is similar to Microsoft Windows applications.

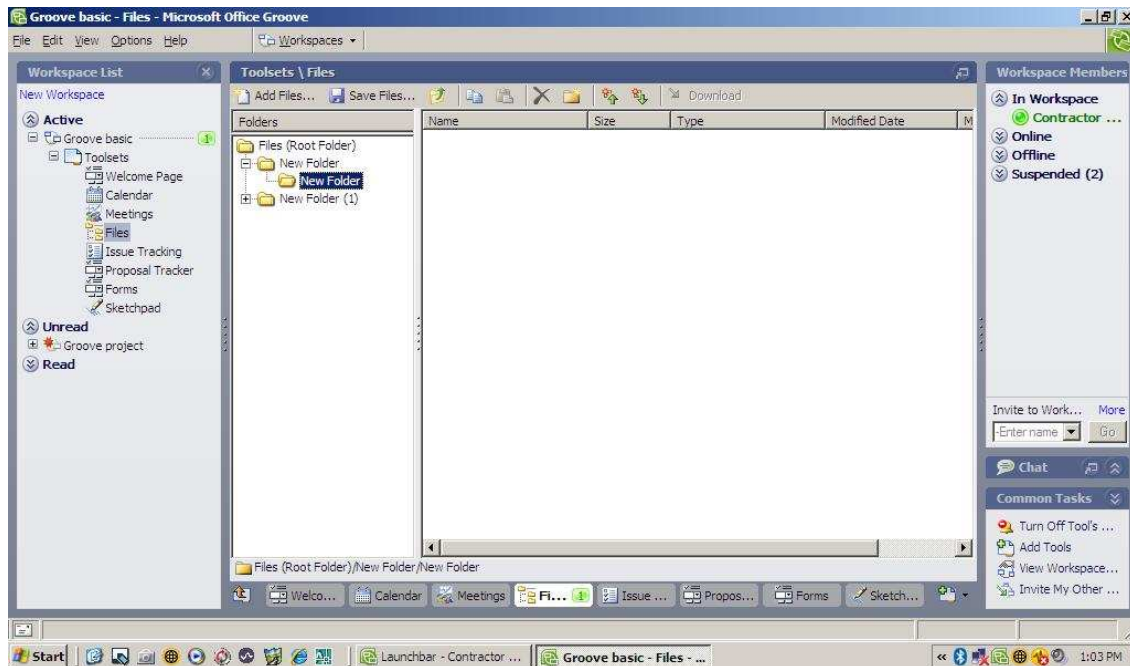


Figure 11. Groove files tool default-view

This tool will be utilized multiple times as separate modules for sample construction projects' contracts, drawings & specifications, estimates, schedules, and progress documentation.

5.4 FORMS TOOL

Forms tool facilitate project teams to create forms and templates from scratch. This tool does not provide any ready-to-use templates as a result giving the sole control to the user in defining the layout and the information on the module. Users decide on the information they would like to see on the template and the module and create unique templates and modules that best serve to the needs of the project. Figure 12 illustrates the initial view when a new template and a module need to be created using this tool. This tool is utilized to create Change Order and Chang Directive modules.

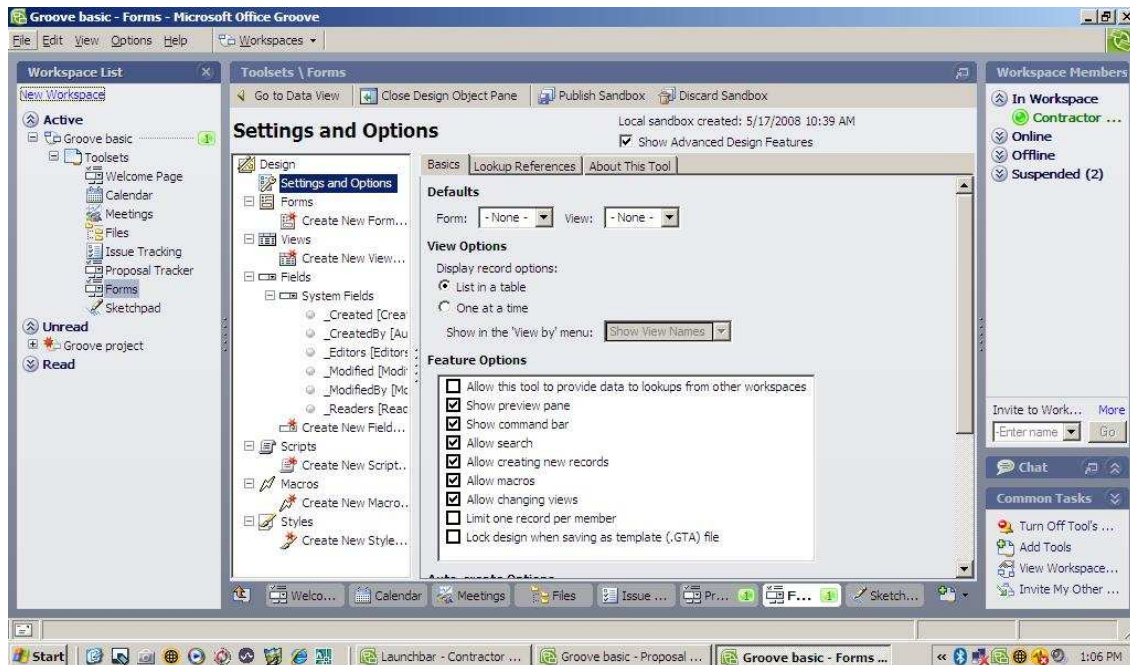


Figure 12. Groove forms tool default-view

5.5 ISSUE TRACKER

Issue Tracker tool is selected to be used as a RFI Module, mainly because its current content includes information that is relevant to RFIs as well. One of the most importantly features of this tool is that it automatically generates and assigns tracking numbers to each form making it easier to organize and track RFIs together with all their responses. However, with its current content this module still requires modification when AIA recommendations for RFIs are considered. As Figure 13 illustrates, the default view of the tool is showing the non-customized version of the issue template which will be customized into a RFI template in the following section.

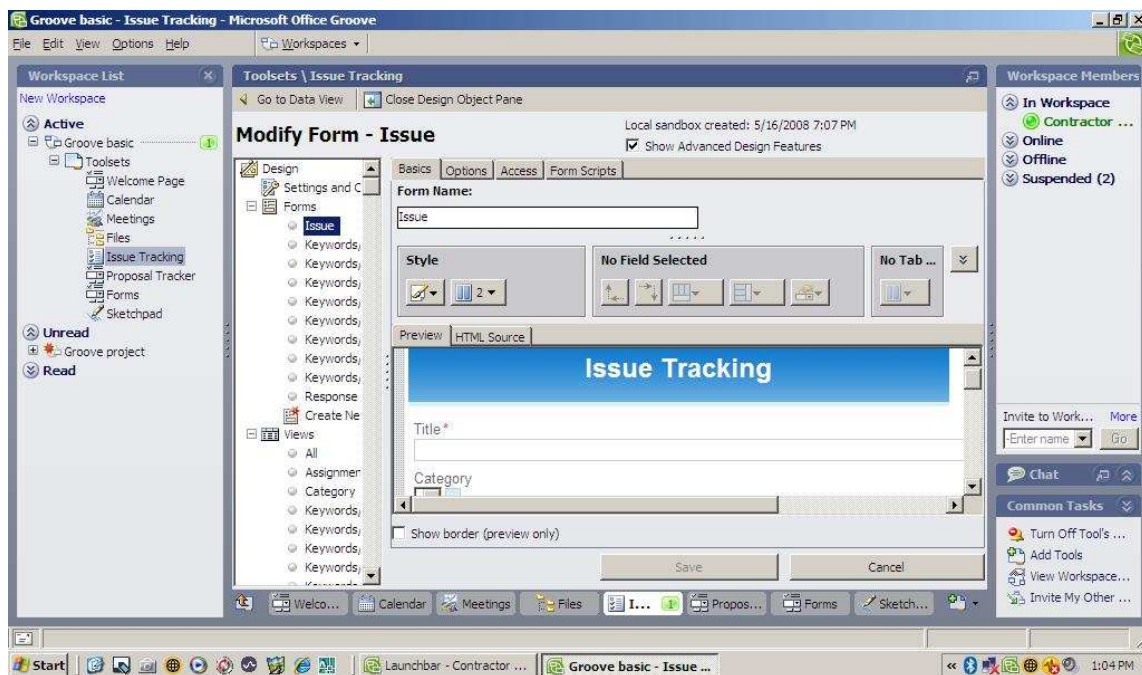


Figure 13. Groove issue tracking tool default-view

5.6 PROPOSAL TRACKER

This tool is adopted to be used as RFP Module. As shown in Figure 14, the tool's built-in layout and content already provides certain information regarding the proposal manager, proposal deadline, degree of importance as high, medium, low, opportunity description and business justification for the proposal as well as the quantities and units that price is requested for. However, this tool still requires modification based on the AIA recommendations for RFPs.

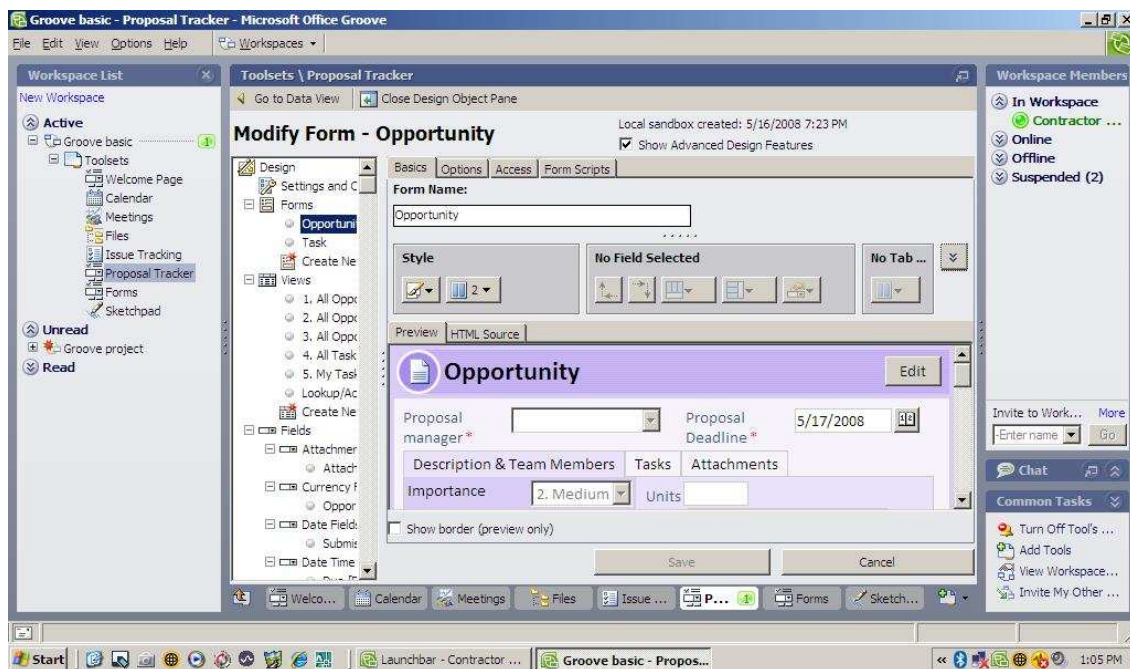


Figure 14. Groove proposal tracker tool default-view

5.7 SKETCHPAD TOOL

This tool provides an additional visual platform in support of other modules or can be used independently as well. It can be used in conjunction with the RFI module to describe the problem areas visually either by sketching on the white board or by inserting real pictures from the site and marking on it. Another important feature of this tool is its ability to support real-time and interactive sharing among the users. Users can work on the same sketch at the same time and can view each others changes in real-time. This feature provides a unique opportunity for fast and interactive communication and collaboration for construction projects. Tools' default view is shown in Figure 15.

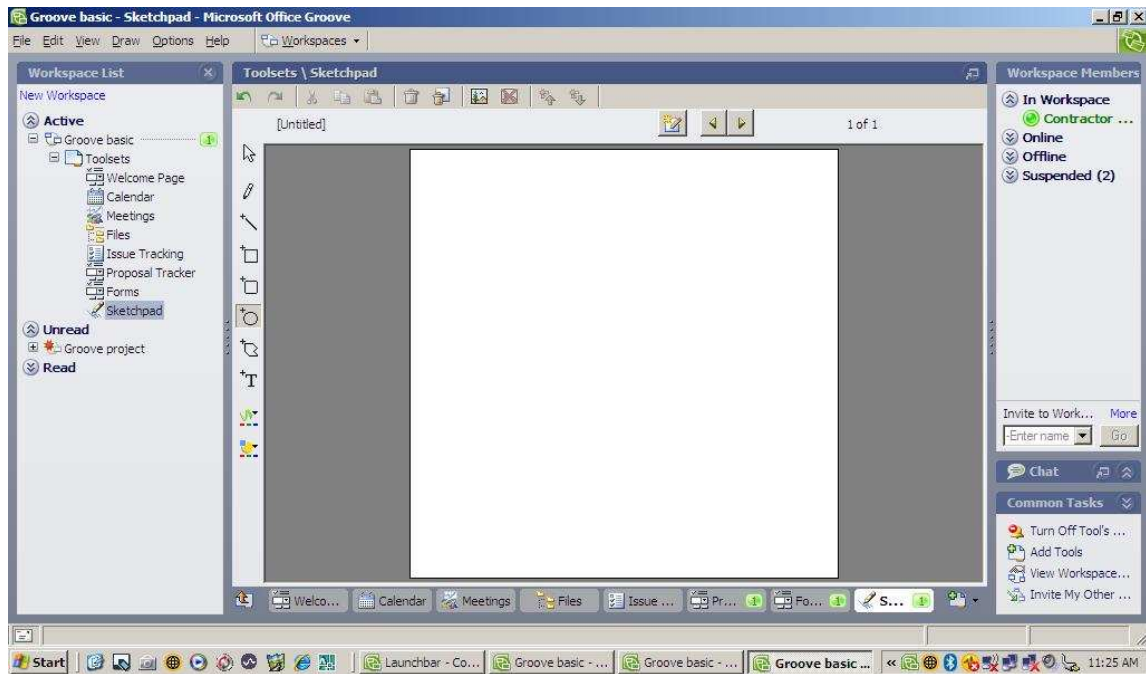


Figure 15. Groove sketchpad tool default-view

6 SAMPLE CONSTRUCTION PROJECT AND TEMPLATE ILLUSTRATION

In this section, the adaptation and customization of selected Groove tools are illustrated for a sample construction project. The selected project is a renovation project in Langford Building A of the Texas A&M University College Station campus. This project was undertaken by the Department of Construction Science at College of Architecture in 2007. The purpose of the project was to re-define the existing office spaces (total area of 897 square feet), and create office spaces for the head and associate head of the department. With this new organization, a reception area and a meeting room for the department were also created. The project scope included the following activities:

- ***selective demolition*** of partition non-load bearing walls between office rooms, removal of doors and associated metal frames, and existing carpets.
- ***drywall construction*** using single ply with metal stud, and gypsum wallboards (4-foot in width, 8-feet in length, and 5/8 inches in thickness) applied on each side of the construction with vinyl bases (4½ inches thickness).
- ***installment of doors, frames and trimming*** using wood flush doors and frames and trims to both sides.
- ***carpeting*** of office rooms by applying nylon carpeting on direct cement.
- ***painting*** of selected room walls and corridor walls which were affected from selective demolition.

The project was finalized in 27 work days, with a budget of 50,000 dollars and the project was contracted to Alpha Contractors.

6.1 TEMPLATE WORKSPACE DESCRIPTION

Table 2 provides a list of these modules with their descriptions, intended uses and the Groove tools used in their development.

Table 2.

Groove Sample Construction Project Workspace Structure

Modified Module Name	Description	Original Groove Tool Used
Welcome Page	Module descriptions are provided, steps for creating new modules & templates are explained, and role permissions are displayed	Welcome Page (ad hoc)
Project Calendar	Project start and finish dates, as well as important events and milestones are marked	Calendar Tool
Meetings	Meetings are scheduled, agendas and meeting minutes are created/edited/distributed	Meetings Tool
Contracts	Project's Main and Sub Contracts (DOC, PDF,...) are filed	Files Tool
Drawings	Project drawings (CAD, PDF,...) are filed	Files Tool
Specifications	Project specifications (DOC, PDF,...) are filed	Files Tool
Estimates	Project estimates (XLS, DOC, PDF,...) are filed	Files Tool
Schedule	Project schedules (MPP, P3,...) are filed	Files Tool
Progress Documentation	Project performance reports, analysis and forecasts (DOC, XLS, PDF, MDI, ...) are filed	Files Tool
RFI Tracker	RFIs are custom created, modified, responded and stored with unique identification numbers	Issue Tracking
RFP Tracker	RFPs are custom created, modified, assigned, responded and stored with identification numbers	Proposal Tracker (ad hoc)
Change Order Tracker	Change Order Tracker is used for issuing and tracking Change Orders	Forms Tool
Change Directive Tracker	Change Directive Tracker is used for issuing and tracking Change Directives	Forms Tool
Internal Project Communications (IPC)	IPCs are custom created, modified, responded, and stored with unique identification numbers	Issue Tracking
Sketchpad	Sketches are drawn, picture files (JPG) are inserted and marked on	Sketchpad
Punch list	Punch lists and closing documentations (DOC, XLS,...) are filed	Files Tool

As described in Table 2, several different modules are developed for the sample construction workspace using the available Groove tools. It is important to note that Groove provides users with real flexibility for customization. Each of these modules can

be customized differently with different layouts and content based on the differing needs of projects.

6.1.1 Project Calendar Module

Project Calendar tool on Microsoft Groove is adopted without any modifications with the exception of the tool's name. Calendar Tool is re-named as Project Calendar for this sample construction project.

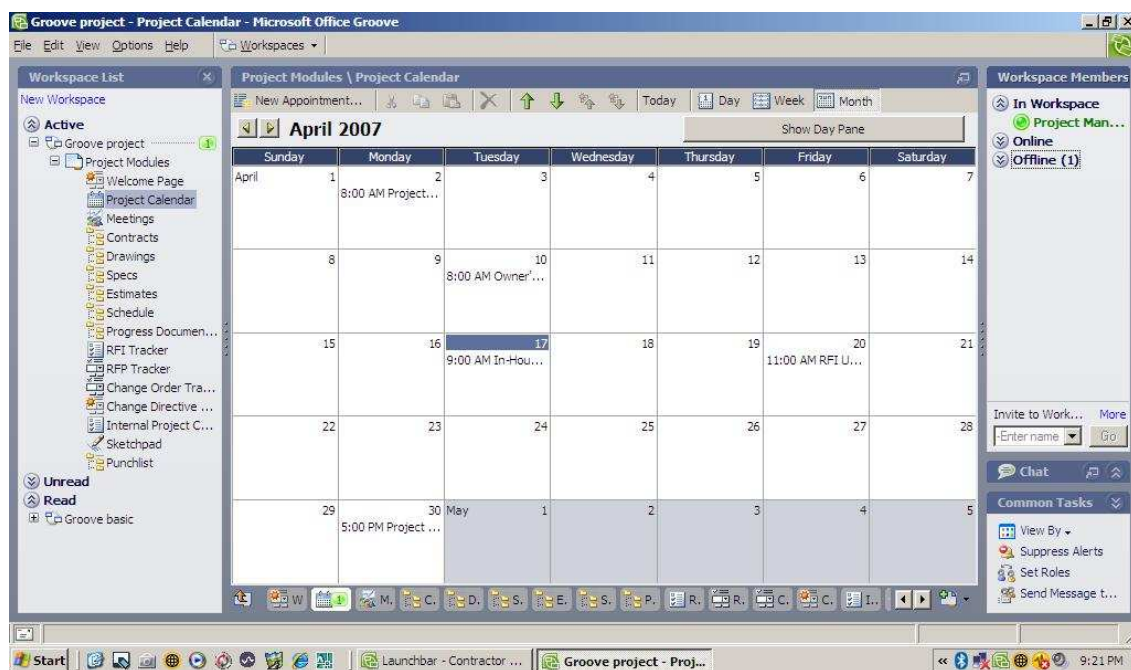


Figure 16. Groove project calendar customized view

As illustrated on Figure 16, during this project, project team marked five important dates and milestones. The project start date marked as April 02, 2007 and project finish date was marked as April 30, 2007. Several other important events are marked on the calendar such as the Owner's meeting, in-house meeting, and RFI update meeting.

To mark an appointment on the calendar one should click on the “New Appointment” button on the toolbar as can be seen in Figure 16. Display options are also changed from the toolbar choosing one of the display options as day, week, or month.

6.1.2 Meetings Module

Meetings tool on Groove coordinates meetings between project team members. This tool on Microsoft Groove is adopted without any modifications.

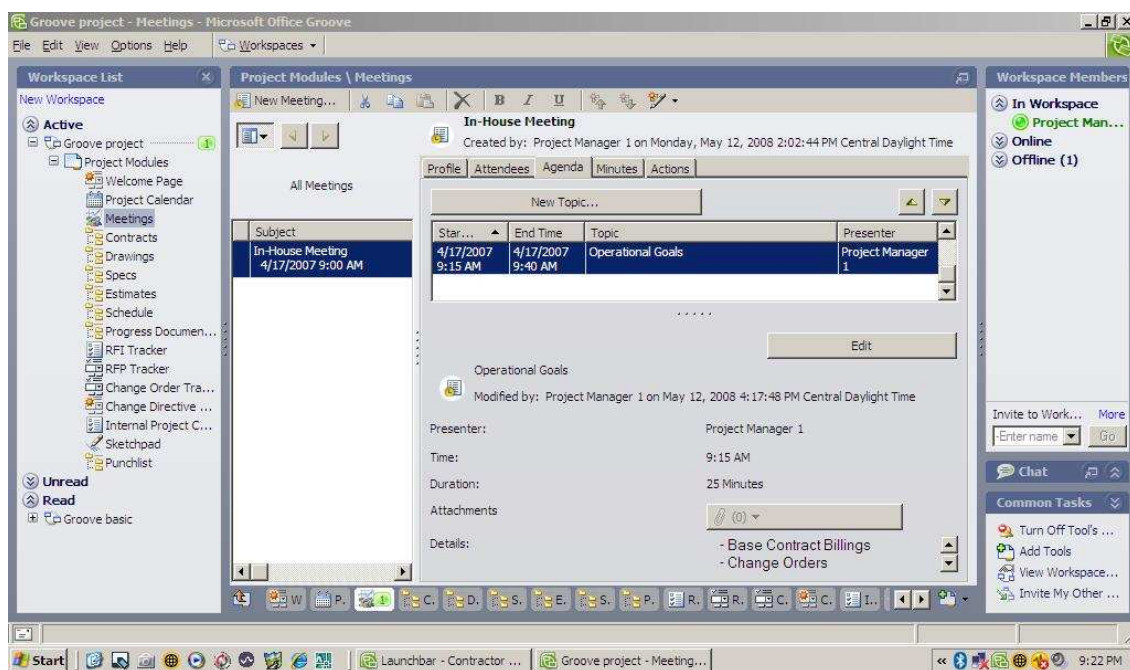


Figure 17. Groove meeting module customized view

As shown in Figure 17, the project team conducted three meetings one of which was an in-house meeting. The agenda of that meeting included topics concerning base contract billings, change orders, overall schedule performance, and submittals.

In order to create a new meeting on the module “New Meeting” button on the toolbar should be selected and information concerning the meeting such as attendees, meeting agenda, meeting minutes and actions are entered.

6.1.3 Contracts Module

Contracts Module is created using Groove Files Tool. This module is modified to store and access project contracts. Groove Files Tool is re-named as Contracts.

The Main and Sub-Contract folders are created under the “Contracts” root folder to store the sample projects’ contracts (Figure 18). Unstructured documents, such as contracts, are best displayed using Groove Files Tool.

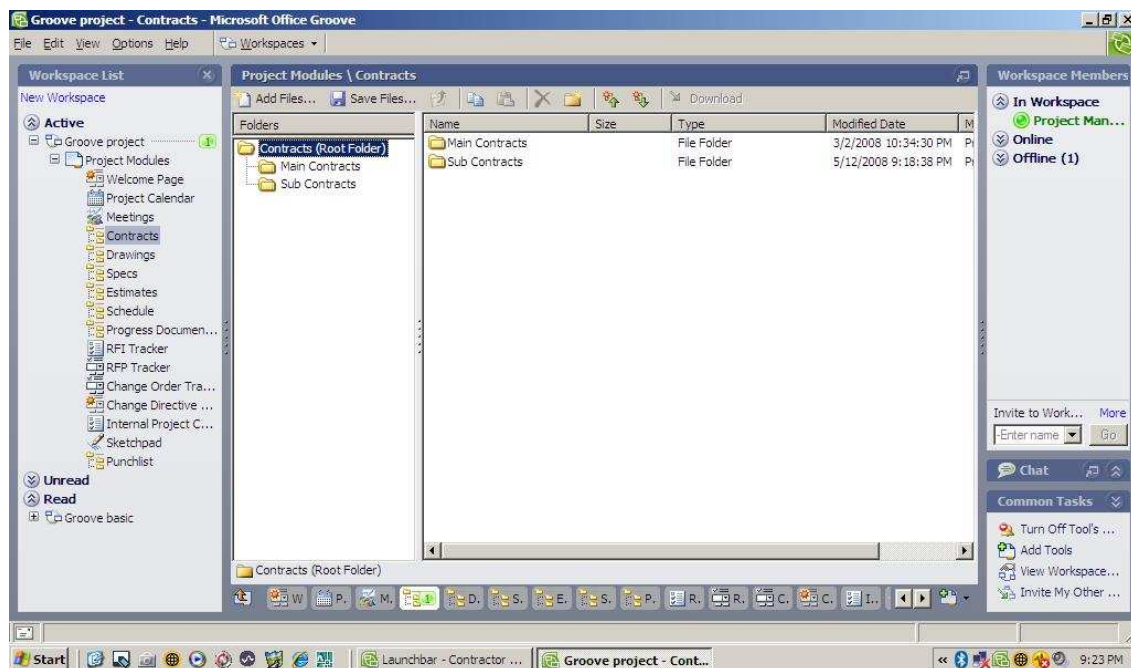


Figure 18. Groove contracts module view (Customized from files tool)

As shown in Figure 18, folders are created, and files are added by using the “Create new folder and “Add files” buttons on the toolbar. The processes of adding/deleting folders and files in this module are no different than any folder/file adding processes of any Microsoft Office product.

Figure 19 shows the front page of the main contract signed between the Texas A&M University and Alpha Contractors regarding the Construction Science Department renovation project. This document together with its subcontracts is uploaded to the Contracts Module.

<p>TAMUS Form C-5 03/07</p>	<p>THE TEXAS A&M UNIVERSITY SYSTEM AGREEMENT BETWEEN OWNER AND CONTRACTOR</p> <p>THIS AGREEMENT is made on April 2, 2007 between Alpha Contractors, hereinafter called the "Contractor," and the Board of Regents of The Texas A&M University System, hereinafter called the "Owner." Capitalized terms used in this Agreement, unless otherwise defined herein, shall have the meanings ascribed to them in the Owner's current Uniform General and Supplementary Conditions (the "UGSC").</p> <p>WITNESSETH, that the Contractor and the Owner, for the consideration hereinafter named, agree as follows:</p> <p style="text-align: center;">ARTICLE I SCOPE OF WORK</p> <p>The Contractor shall furnish all the materials and perform all the Work called for in the Contract Documents entitled: TAMU Construction Science Department Renovation Project which includes selective demolition of the existing room walls, removal of the carpet and construction of new partition walls as well as new carpeting and painting on the selected walls and corridors.</p> <p>Prepared by: Texas A&M University System</p> <p style="text-align: center;">ARTICLE II TIME OF COMPLETION</p> <p>The Contractor shall begin Work on the date indicated in the Notice to Proceed issued by the Owner's representative. The Work to be performed under the Contract shall be substantially completed in twenty seven (27) consecutive calendar days, plus any extended days approved by the ODR, in accordance with the UGSC, and shall be fully and finally completed within thirty (30) days thereafter. For each consecutive calendar day after the date of Substantial Completion, plus any extensions of time granted by Change Order, that the Work is not substantially completed, Contractor shall pay to Owner liquidated damages in accordance with the UGSC.</p> <p style="text-align: center;">ARTICLE III THE CONTRACT SUM</p> <p>The Owner shall pay the Contractor for the performance of the Contract, subject to additions and deductions provided therein, the sum of fifty thousand dollars (\$ 50,000)</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Contract Award Amount</td> <td style="width: 50%;">Separation of Costs</td> </tr> </table> <p style="text-align: center;">ARTICLE IV PROGRESS PAYMENTS</p> <p>The Owner shall make periodic payments as approved by the ODR in accordance with the UGSC.</p>	Contract Award Amount	Separation of Costs
Contract Award Amount	Separation of Costs		

Figure 19. Agreement between the owner and the contractor

In case of more than one File Tool is needed on the workspace, a new File Tool can be added to the workspace with the following procedure: “File Menu...Tool...Files...” This process can be repeated as many times as needed for any Groove Tool listed on the Groove Tools menu (calendar, forms, sketchpad etc.).

6.1.4 Drawings Module

Drawings module is created using Groove Files Tool. This module is modified to store and access project related drawings and the tool itself is re-named as Drawings. As shown in Figure 20, two folders are created under the drawings root folder and named as CAD and PDF drawing files for the sample project. The sample project had three drawings showing the existing layout, demolition plan and new layout for the renovation.

The same folder and file adding/deleting processes described in the Contracts Module apply to the Drawings Module as well. An open view of one of the files that is uploaded on the module is shown in Figure 21.

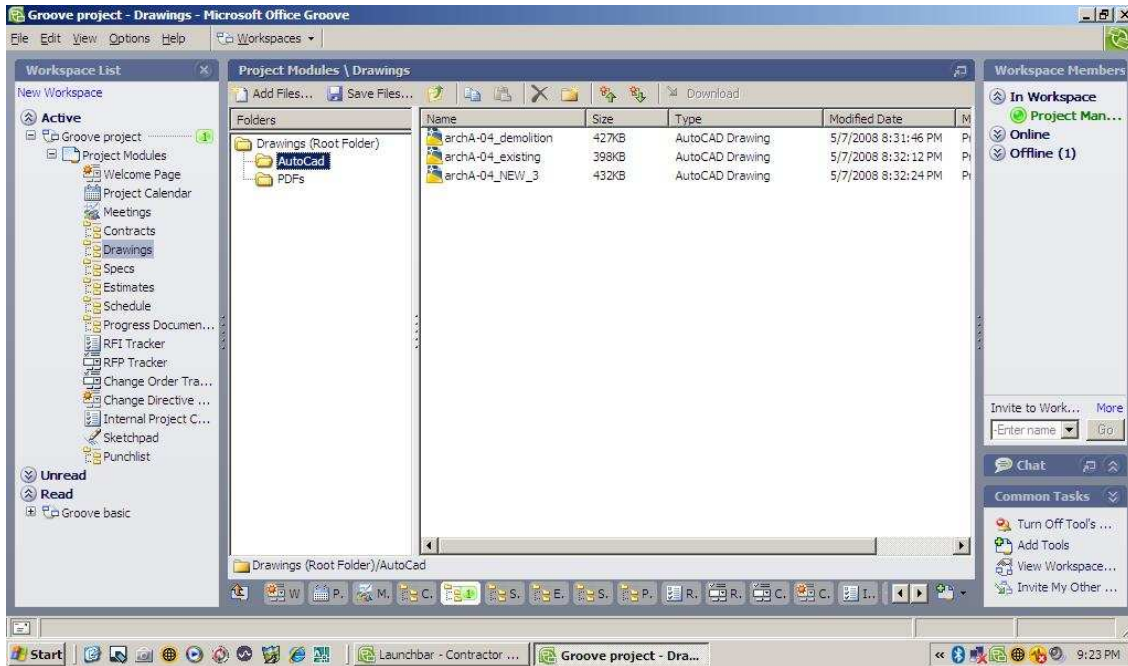


Figure 20. Groove drawings module view (Customized from files tool)

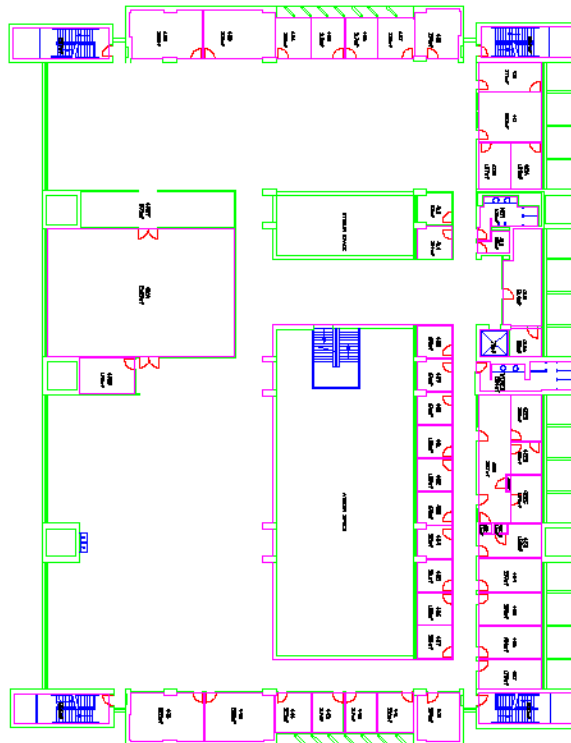


Figure 21. Pre-construction drawing of sample project

Figure 21 shows the department's office layout before the construction took place. Other drawings such as the demolition and the new layout are also uploaded to the same module.

6.1.5 Specifications Module

Specifications module is created using Groove Files Tool. It is designed to store and access project specifications and the tool itself is re-named as Specifications. For this sample project, one folder is created under the specs root folder and named as "Project Specifications" as illustrated in Figure 22. This sample project included one set of specifications which provided details regarding the demolition process, recycling, material selection and acceptance criteria.

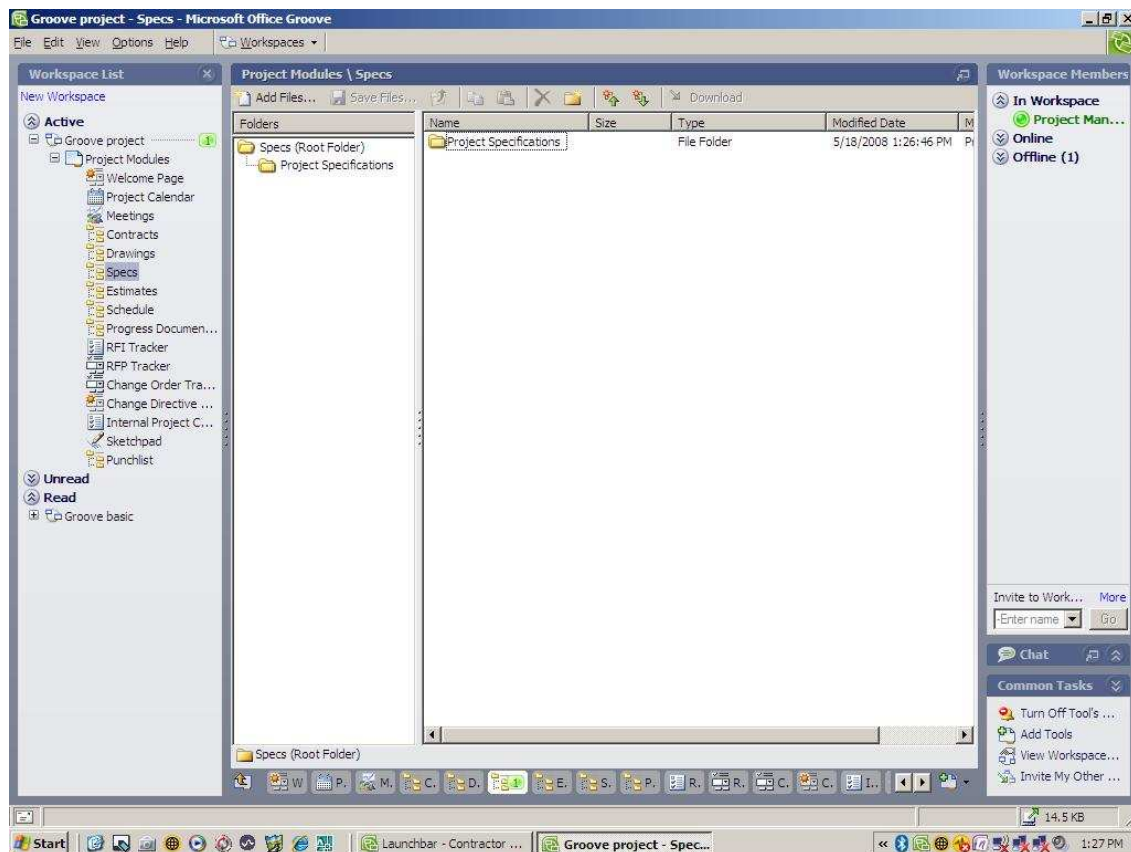


Figure 22. Groove specifications module view (Customized from files tool)

The same processes of adding/deleting files and folders described in the Contracts Module can be followed for the Specifications Module as well.

6.1.6 Estimates Module

Estimates module is also created using Groove Files Tool. Sample project had one quantity takeoff in “.XLS” format file. Construction companies may also store their project related cost estimates, budgets, and forecasts in this module. As shown in Figure 23, the sample project used four subfolders that were created under the Estimates root folder for quantity takeoffs, cost estimates, budgets and forecasts.

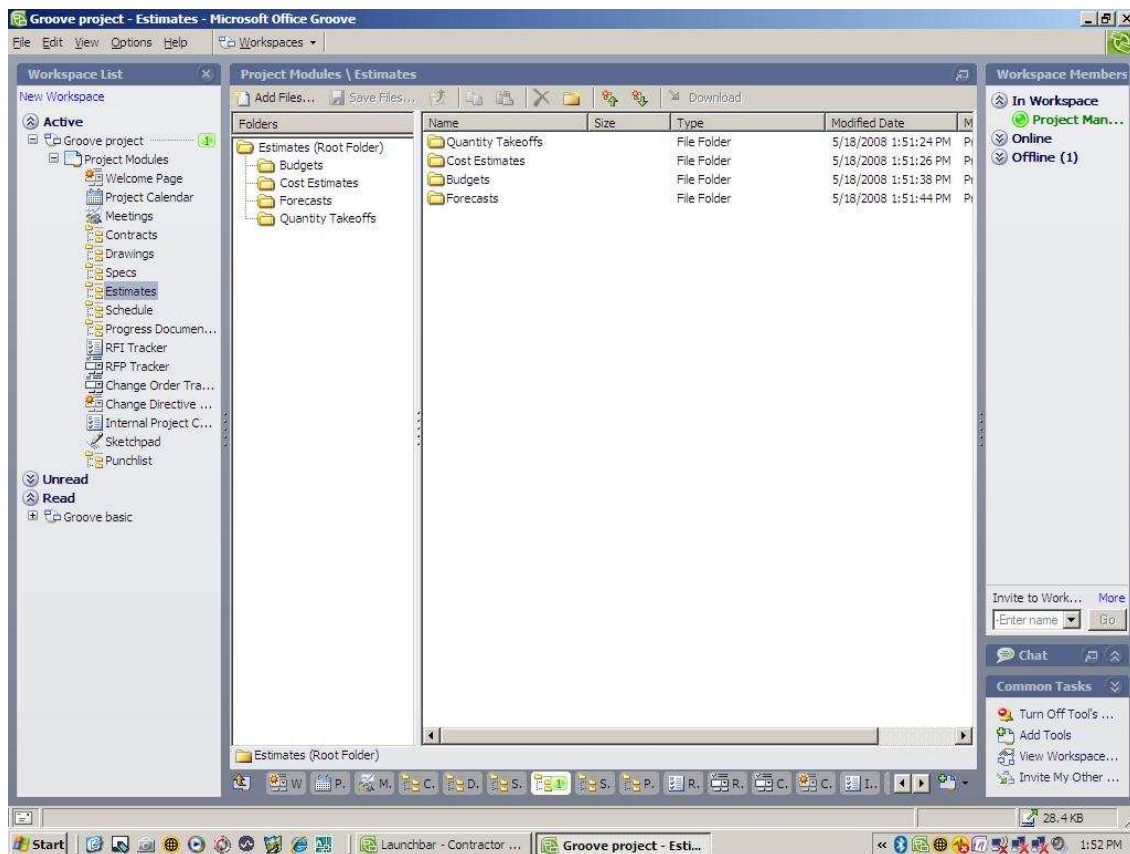


Figure 23. Groove estimates module view (Customized from files tool)

The same processes of adding/deleting files and folders described in the Contracts Module can be followed for the Estimates Module as well. Table 3 is an example of the sample projects takeoff sheet that is uploaded to the Estimates Module.

Table 3.

Sample Project Quantity Takeoff

#	Item	Quantity	Unit
	Selective Demolition		
1	Remove 5 1/4" metal frame non-load bearing partition wall between rooms 425 & 426 to underside of A/C boxing	36	SF
2	Remove 5 1/4" metal frame non-load bearing partition wall between rooms 425, 426 and corridor to underside of A/C boxing.	160	SF
4	Remove 3' x 7' 6" wood doors and associated metal frame and associated ironmongery and set aside for reuse.	4	EA
5	Remove existing carpet from rooms 424 & 427 and prepare concrete floor to receive new carpet.	363	SF
	Room 423		
6	8'-0" high 5/8" Gypsum Partition on 2" frame	55	SF
7	4 1/2" vinyl base to new partition	8	LF
8	3' 0" x 7'6" x 1 3/4" wood flush door & frame with mortice lock & knob. 2 1/2" trim to both sides.	1	EA
	Room 424		
9	Close existing door opening with 5/8" Gypsum Partition on 2" frame	28	SF
10	4 1/2" vinyl base to new partition to match existing	7	LF
11	Form new door opening in existing 5 1/4" metal frame non-load bearing partition wall between rooms 424 & 425 and re-position door & frame removed from room 424	1	EA
12	Nylon carpet on direct cement	21	SY
13	Latex paint finish to walls only	731	SF
14	Latex paint finish to underside of A/C boxing	45	SF
	Rooms 425/426		
15	19'-0" x 8'-0" hollow metal frame - fully glazed store front with 6" deep horizontal mullion. 3'-0" x 7'-6" wood door with 2 - 2' 0" wide glazed panels, mortice lock & knob & self closing device	1	EA
16	8'-0" high 5/8" Gypsum Partition on 2" metal frame to underside of A/C boxing.	80	SF
17	4 1/2" vinyl base to new partition to match existing	14	LF
18	Form new door opening in existing 5 1/4" metal frame non-load bearing partition wall between rooms 426 & 427 and re-position door & frame removed from room 426	1	EA
19	Form door opening in new 5 1/4" metal frame non-load bearing partition in rooms 425 & 426 and re-position door & frame removed from room 425	1	EA
20	Nylon carpet on direct cement	42	SY
21	Latex paint finish to walls only	1637	SF
	Latex paint finish to underside of A/C boxing	90	SF
22	Room 427		
23	Close existing door opening with 5/8" Gypsum Partition on 2" frame	1	EA
24	4 1/2" vinyl base to new partition to match existing	7	LF
25	Nylon carpet on direct cement	21	SY
26	Latex paint finish to walls only	731	SF
27	Latex paint finish to underside of A/C boxing	45	SF
	Coridoor		
28	Latex paint finish to effected walls	168	SF

In Table 3, the sample construction project has 196 square feet of existing non-load bearing partition walls to be demolished and 363 square feet of existing carpets to be removed. After the demolition and removal, a total of 162 square feet Gypsum partition walls, 36 linear feet of vinyl base, and 84 square yards of new nylon carpet are planned to be installed, and finally 3,447 square feet of latex paint application is scheduled for the walls.

6.1.7 Schedule Module

Schedule tool is created using Groove Files Tool. The sample project did not have a digital schedule created however, a baseline and an update schedule were recreated using MS Project scheduling software. If the company's choice of scheduling software is Primavera, it can also be included in the workspace to view and edit ".XER" format files.

In Figure 24, two separate schedule folders, baseline and updates, are added under the Schedule root folder. Baseline folder stores contractually approved baseline schedule of the project. Update folder stores the schedules that are updated after the contract to mark progresses or introduce delays to the baseline schedule. The same processes of adding/deleting files and folders described in the Contracts Module can be followed for the Schedule Module as well.

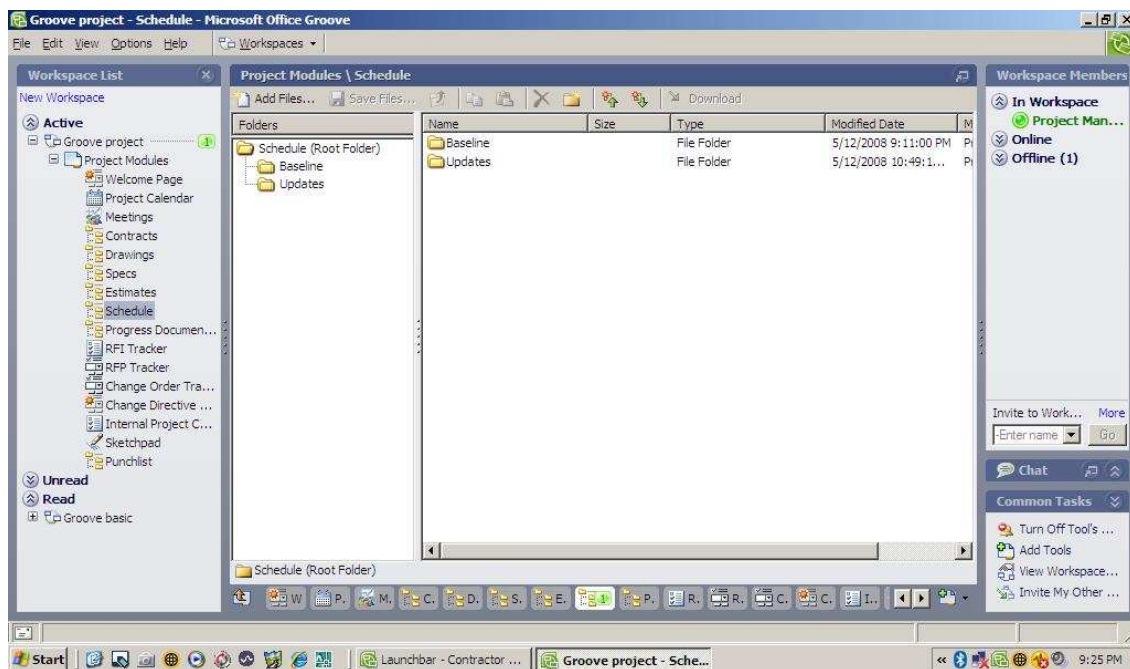


Figure 24. Groove schedule module view (Customized from files tool)

Figure 25 shows the updated schedule of the project as of April 22, 2007. According to the baseline schedule, installment of hallow metal frame and wood doors was supposed to take only two days. However, a manufacturing problem on the frame led the project team to issue an RFI resulting in one day of delay on that specific activity. Instead of taking two days, the installment process took three days shifting the schedule further away from the initial project end date.

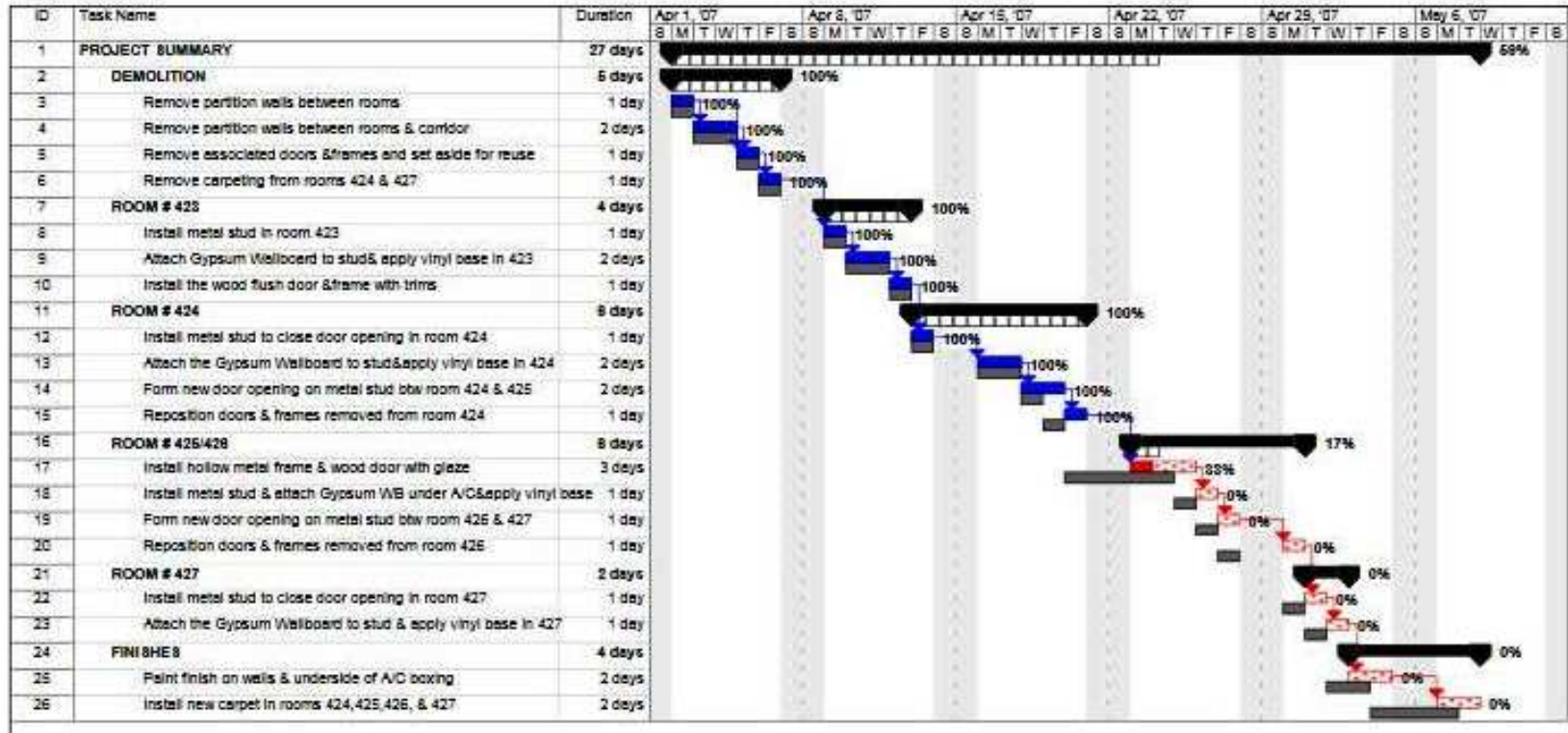


Figure 25. Project updated schedule MS project view

6.1.8 Progress Documentation Module

Progress Documentation module is created using Groove Files tool. This module can be used to file field reports, project performance reports, analysis, and forecasts. Files in formats such as “.XLS”, “.DOC”, “.PDF”, and “.MDI” can be accessed through this module.

The same processes described in the Contracts Module can be followed for the Progress Documentation Module. As shown in Figure 26, Progress Documentation Module has one root folder named as “Progress Documentation” with no further sub files.

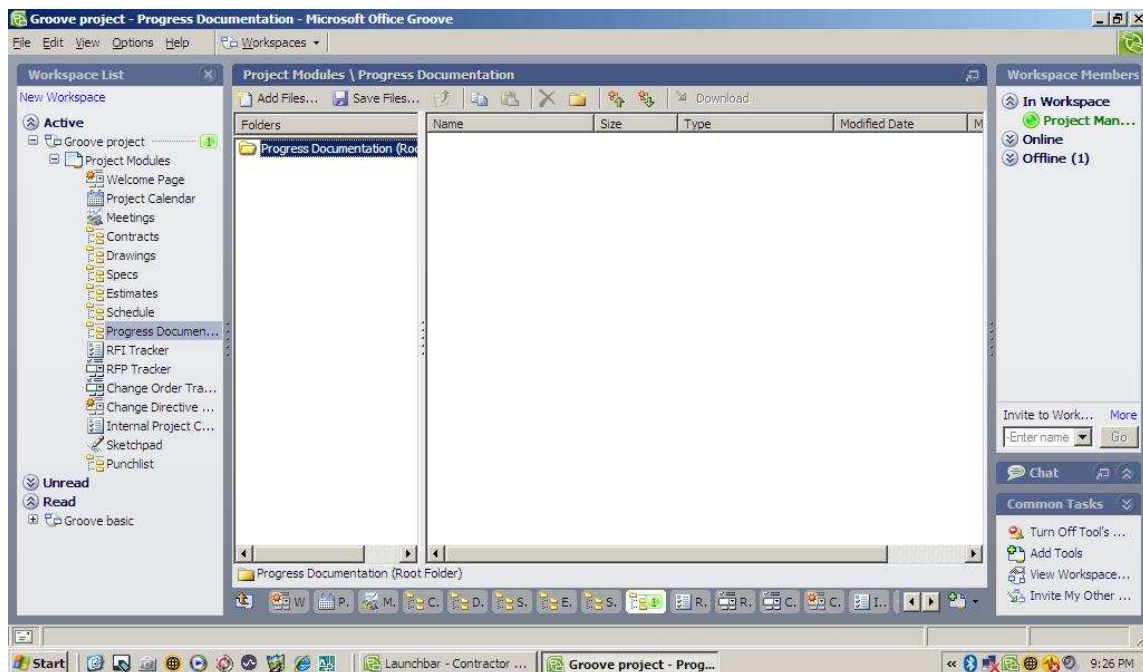


Figure 26. Groove progress documentation module view (Customized from files tool)

6.1.9 RFI Module

RFI module is an adapted version of Groove “Issue Tracking” tool. Although, it is not specifically designed for the RFI process, this tool can easily be adapted to a RFI module. This tool, with certain modifications, provides the level of detail necessary for RFIs.

RFI modules are one of the most visited modules in any PMCS, due to the overwhelming number of RFIs issued in a single project. However, a more serious problem acknowledged by the industry, is the long RFI response times. NIST (2004) found out 10 business days as the average response time for a RFI. By using Groove RFI module, it may not be possible to decrease the number of RFIs issued, but it is very likely that response times can be shortened and the functionality can be enhanced substantially.

If the Issue Tracking Tool is not visible on the workspace, steps described on the tool activation process in the Contracts module section can be followed to activate the tool. Once activated, rename the module as “RFI Tracker”.

In order to adapt this tool to a RFI module, a two-step procedure must be completed. First, the existing template has to be modified. Issue Tracking Tool’s built-in “Issue” template provides certain level of detail by default. Information such as the title, ID (non-editable), category, subcategory, entered by, on, originated by, individual, description, and attachment options make up the existing form. However, according to AIA Guidelines, RFI should include the following information at minimum: (a) project name, (b) project number, (c) RFI number, (d) issue date, (e) requested reply date, (f) disciplines affected, (g) priority (1 to 5), (h) RFI description, (i) referenced drawing and specification number, (j) sender’s recommendations, (k) receiver’s reply, (l) answered by, (m) date answered. As a result, the existing “Issue” template is modified in line with the AIA’s guidelines and re-named as “RFI” form. The following steps identify the

processes that have to be followed when modifying the template and Figure 28 shows an example of one of the RFIs created for the sample construction project:

- Step 1: Click on “Designer...” on the toolbar
- Step 2: Choose “Modify Form...” and then “Issue”
- Step 3: Edit “Form Name” (i.e. RFI)
- Step 4: Select “Fields” (i.e. Author)
- Step 5: If needed “Create New Fields...” (i.e. RFI No.)
- Step 6: Change the “Style” of the fields
- Step 7: “SAVE”
- Step 8: “Publish Sandbox”

Once the form is modified, second step is to customize the current view and organization of the module itself. This process enables the project team decide on how all the RFIs will be organized and hence, viewed on the module. By following the steps described below, project teams can easily customize the organization, order and displayable formats of all the RFIs on the RFI module.

- Step 1: Click on “Designer...” on the toolbar
- Step 2: Choose “Modify View...” and then “All...”
- Step 3: Edit “View Name” (i.e. RFI)
- Step 4: Select “Fields” (i.e. Author)
- Step 5: If needed “Create New Fields...” (i.e. RFI No.)
- Step 6: “SAVE”
- Step 7: “Publish Sandbox”

With the completion of these two processes, a RFI module with editable custom RFI forms is obtained. Figures 27 and 28 show the organization of all the RFIs on the module created for the sample project and document view of a sample RFI respectively.

The screenshot displays the Microsoft Office Groove interface for the 'Groove project - RFI Tracker'. The main window is titled 'Project Modules | RFI Tracker' and contains a table of RFI entries. A detailed view of a selected RFI entry is shown below the table.

ID	Entered by	Requested Rep...	Title	Priority (1 to 5)	Replied on
KYUL-9C372FB3E	Project Manager 1	4/9/2007	Unclear Dimensions	5	
KYUL-9E28F58DE	Project Manager 1		Re: Unclear Dimensions		4/8/2007
KYUL-9E03633BE	Project Manager 1	4/7/2007	Storage for removed doors	3	
KYUL-9E043E888	Project Manager 1		Re: Storage for removed		4/9/2007
KYUL-9E29C61F7	Project Manager 1	4/6/2007	Scrap carpet	2	
KYUL-9E29F1995	Project Manager 1		Re: Scrap carpet		4/6/2007
KYUL-9E2A6EA41	Project Manager 1	4/18/2007	Hallow Metal Frame and	5	

The detailed view for the selected RFI entry (ID: KYUL-9E2A6EA41) shows the following information:

- Title: Hallow Metal Frame and Wood Door
- From: PM1
- Issue Date: 4/12/2007
- ID: KYUL-9E2A6EA41
- To: Owner
- Requested: 4/18/2007
- Reply
- Date:
- Subcategory

The interface also includes a 'Workspace List' on the left, a 'Workspace Members' panel on the right showing 'Project Man...' as online, and a taskbar at the bottom with the Start button and various application icons.

Figure 27. Groove RFI module view (Customized from issue tracking tool)

RFI Tracking

Title *	Hallow Metal Frame and Wood Door		ID:	KYUL-9E2A6EA41	
From:	PM1		To:	Owner	
Issue Date:	4/12/2007		Requested Reply Date:	4/18/2007	
Category	Doors & Frames		Subcategory		
Priority (1 to 5)	5		Status	Pending	

Description:

B / I Fully glazed hallow metal frame and the wood door when installed as it is, wood door opens to left although it should open to right. This is a manufacturing problem so we can request the manufacturer to fix this. However, this might increase the Contract Time by at least two weeks.

Our recommendation is to alter the sides of the existing frame so that the inside of the frame will face outside. This will solve the problem of the door opening to the wrong side without major aesthetic concerns. Nevertheless, as marked on Sketchpad #1, the screws will be exposed.

Please advise if this solution is acceptable for you.

Last Modified By: Project Manager 1 On: 5/13/2008 9:43 AM

Ongoing Remarks:

B / I

Attachments:

Figure 28. Groove RFI tracking sample document view

6.1.10 RFP Module

RFP Tracker is an adapted version of one of Groove's ad hoc tools called the "Proposal Tracker". This tool can not be accessed through the workspace tools menu. This is an ad hoc tool developed by Microsoft and can only be downloaded from Microsoft website.

The main purpose of this tool is to create a platform where proposal requests can be made, assigned to team members as tasks, and tracked. Existing tool provides a certain level of detail for issuing and tracking proposals. The built-in opportunity form is designed to explain the business justification of the proposal and includes some qualitative and quantitative details such as the proposal deadline, proposal manager, the

units and values. However, in accordance with AIA's guidelines, this module is modified to be a better fit for the Construction Industry.

Once the "Proposal Tracker" tool is downloaded from Microsoft Online, it can be either adopted as it is or can be modified based on the needs of the project. Creating a new form is also an option. In this sample project, the existing form is modified. In order to do that, two steps have to be completed. First, the existing template has to be modified. The following steps are required for this modification.

- Step 1: Click on "Designer..." on the toolbar
- Step 2: Choose "Modify Form..." and then "Proposal"
- Step 3: Edit "Form Name" (i.e. RFP)
- Step 4: Select "Fields" (i.e. Author)
- Step 5: If needed "Create New Fields..." (i.e. RFP No.)
- Step 6: Change the "Style" of the fields
- Step 7: "SAVE"
- Step 8: "Publish Sandbox"

Second step is to customize the current view and organization of the module itself. This process enables the project team decide on how all the RFPs will be organized and hence, viewed on the module. By following the processes described below, project teams can easily customize the organization, order and displayable formats of all the RFPs on the module.

- Step 1: Click on "Designer..." on the toolbar
- Step 2: Choose "Modify View..." and then "All Opportunities..."
- Step 3: Edit "View Name" (i.e. RFP)
- Step 4: Select "Fields" (i.e. Author)
- Step 5: If needed "Create New Fields..." (i.e. RFP No.)

Step 6: “SAVE”

Step 7: “Publish Sandbox”

Figures 29 and 30 show the organization of the RFPs on the module and a sample RFP created for the sample construction project respectively.

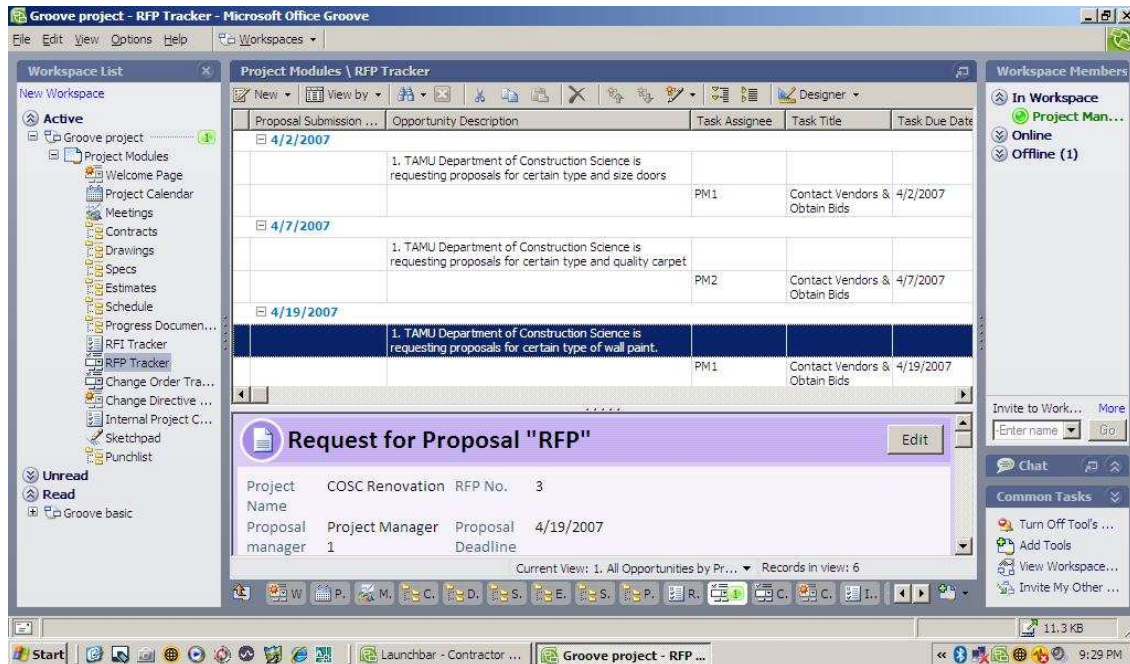


Figure 29. Groove RFP module view (Customized from proposal tracker tool)

Request for Proposal "RFP"			
Project Name	COSC Renovation	RFP No.	3
Proposal manager *	Project Manager 1	Proposal Deadline *	4/19/2007
Requested Owner by		Requested from	General Contractor
Importance	1. High	Units	
		SF	
		Value	3,447
Opportunity description *			
1. TAMU Department of Construction Science is requesting proposals for certain type of wall paint. Texas A&M is requesting proposals from highly qualified vendors with expertise in interior painting.			
2. Acceptable Manufacturers are: Dunn-Edwards or Benjamin Moore. Proposers wishing to submit an "or equal" shall submit samples of proposed substitutes and specifications with their proposal.			
3. Paint Schedule is as follows:			
		Spot-Prime:	Vinylastic (W101) Pigmented Sealer
		1st Coat:	Suprema (W411) Latex Low Sheen Enamel
		2nd Coat:	Suprema (W411) Latex Low Sheen Enamel
4. Vendor shall furnish all labor, equipment, materials and services required.			
5. Vendor shall include a list of current and/or past clients to whom a similar service is provided.			
Our objectives			
Contact Information			

Figure 30. Groove RFP tracking sample document view

6.1.11 Change Order Module

Change Order module is created using Groove Forms Tool. This Tool allows project teams to create templates and modules from scratch. Everything on the module is customizable. This provides the project team with unprecedented flexibility when creating new templates and modules.

AIA recommends that the Change Order forms should include the following information at minimum: (a) project name and address, (b) change order number, (c) date issued, (d) Architect's project number, (e) contract date, (f) contract for, (g) an explanation regarding the new contract change, (h) cost information (original contract sum, net change by previously authorized change orders, the new contract amount), (i) project duration information (any change in the contract time, the new date for substantial

completion) and (j) approvals by the Owner, Architect and the Contractor. These guidelines are followed when creating the Change Order template in this module.

In order to create a Change Order module, one has to complete two steps. First of all, the Change Order template has to be created. This form, based on the needs of the project team can be customized in many ways. To create the template the following steps were followed:

- Step 1: Go to “Forms” Tool on Groove workspace
- Step 2: “Create New Form”
- Step 3: Name the Form (i.e. Change Order)
- Step 4: Choose from pre-defined list of “Fields” (i.e. Author)
- Step 5: If needed “Create New Fields...” (i.e. Change Order No.)
- Step 6: Change the “Style” of the fields
- Step 7: “SAVE”
- Step 8: “Publish Sandbox”

Once the custom form is created, project teams also need a separate module to manage these Change Orders. All Change Orders should be accessed through a separate module where they can be viewed, created, edited, and responded in their own context. To do that, below processes should be followed:

- Step 1: While you are on the “Forms” Tool
- Step 2: Choose “Create New View...” on the design toolbar
- Step 3: Edit “View Name” (i.e. Change Order)
- Step 4: Select “Fields” from a pre-defined list (i.e. Author)
- Step 5: If needed “Create New Fields...” (i.e. Change Order No.)
- Step 6: “SAVE”
- Step 7: “Publish Sandbox”

Figures 31 and 32 show the Change Order module customized view and a sample of the Change Order template created on the module.

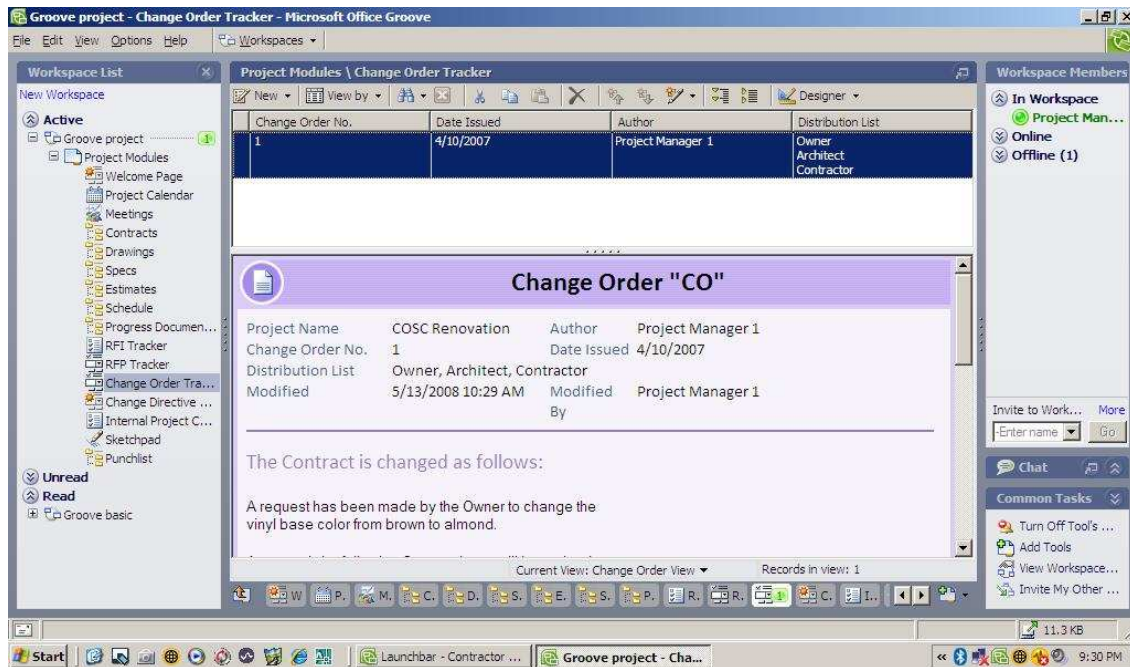


Figure 31. Groove change order module view (Customized from forms tool)


Change Order "CO"			
Project Name:	COOC Renovation	Author:	Project Manager 1
Change Order No.:	1	Date Issued:	4/10/2007
Distribution List:	Owner: Architect: Contractor:		
Modified:	5/15/2008 10:29 AM	Modified By:	Project Manager 1
The Contract is changed as follows:			
			
A request has been made by the Owner to change the vinyl base color from brown to almond.			
As a result the following Contract items will be revised:			
Original Item Description: 4X 1/2" Brown Vinyl Wall Base New Item Description: 4X 1/2" Almond Vinyl Wall Base Unit: Not changed Original quantity: Not changed			
The Architect has determined that new item will be used in place of the original Contract item in accordance with the Specification: Substitution of Materials. Payment will be made under the original item.			
Not valid until signed by the Owner, Architect and Contractor.			
The original Contract Sum was \$50,000.00		Net change by previously authorized Change Orders	
The Contract Sum prior to this Change Order was \$50,000.00		The new Contract Sum including this Change Order will be \$50,000.00	
The Contract Time will be: <input type="checkbox"/> increased <input type="checkbox"/> decreased <input checked="" type="checkbox"/> unchanged		The date of Substantial Completion as of the date of this Change Order therefore is 5/9/2007	
Approvals			
*****	Architect Approval	*****	Contractor Approval
*****	Owner Approval		

Figure 32. Groove change order sample document view

6.1.12 Change Directive Module

Similar to the Change Order module, Change Directive module is created using Groove Forms Tool. This Tool allows project teams to create templates and modules from scratch.

According to AIA Change Directive form should include the following information (AIA, 2001b): (a) project name and address, (b) directive number, (c) date issued, (d) Architect's project number, (e) contract date, (f) contract for, (g) an explanation regarding the new change, (h) proposed cost and time adjustments, (j) approvals by the Owner and Architect and, (k) approval from the Contractor (optional). Change Directive,

when signed by the Owner and the Architect, dictates the Contractor to proceed with the change even without Contractor approval. That's the reason Contractor approval is optional. If the Change Directive is signed also by the Contractor, it indicates full agreement on the proposed changes and adjustments of cost and time between all parties. In this case, following a Change Directive a Change Order is issued.

In order to create a Change Directive module, one has to complete two steps. First of all, the Change Directive template has to be created and a module to manage these Change Directives is needed. The processes described in the Change Order module also apply to the Change Directive module. Please refer to the detail steps described in the Change Order module section to create new templates and organize new modules.

Figures 33 and 34 represent the Change Directive module created for the sample construction project and Change Directive template sample.

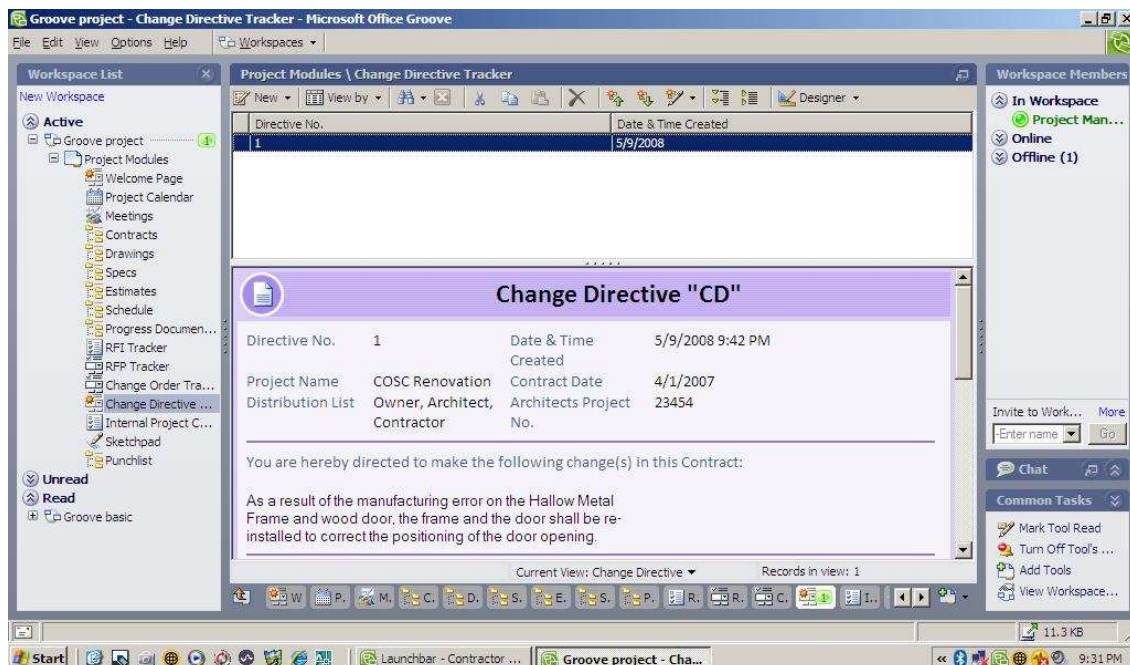


Figure 33. Groove change directive module view (Customized from forms tool)

Change Directive "CD"

Directive No.	1	Date & Time Created	5/9/2008 9:42 PM
Project Name	COSC Renovation	Contract Date	4/1/2007
Distribution List	Owner Architect Contractor	Architects Project No.	23454

You are hereby directed to make the following change(s) in this Contract:

As a result of the manufacturing error on the Hollow Metal Frame and wood door, the frame and the door shall be re-installed to correct the positioning of the door opening.

Proposed Adjustments

1. The Proposed basis of adjustment to the Contract Sum is:

Lump sum	increase	of	\$500.00
Unit Price of	\$62.50	per	hr
The Contract Time is proposed to	remain unchanged	The proposed adjustment, if any, is (in days)	

* When approved by the Owner and Architect and received by the contractor, this document becomes effective immediately as a Construction Change Directive, and the contractor shall proceed with the change (s) described above.

* Contractor approval indicates agreement with the proposed adjustments in Contract Sum and Contract Time set forth in this OCD.

Approvals

Owner Approval (Password Required)	Contractor Approval (Password Required)	Architect Approval (Password Required)
---------------------------------------	--	---

Figure 34. Groove change directive sample document view

6.1.13 Internal Project Communications Module

Internal Project Communications module is adapted from Groove “Issue Tracking” tool. Internal project communications may include any internal and organizational correspondences such as communication of risks and issues identified throughout the project, risk response plans, action plans and assignments. It can be kept confidential by providing access to only desired parties.

In order to adapt this tool to a communications module, two steps have to be completed. First, the existing template has to be modified or a new template should be created. The same processes identified in creating the RFI module also apply to this module. As a result, the same processes described for RFIs can also be used when modifying the Internal Project Communications template. The second step of customizing the current

view and organization of the module itself can also be performed following the processes described in the RFI module.

6.1.14 Sketchpad

Sketchpad tool enables team members to communicate visually and interactively. This tool is very useful on the construction site because it allows users to sketch the problems easily and at the same time making the viewers to see the sketch being drawn in real-time. Users can draw different sketches at the same time or together can work on one sketch at the same time. Another benefit of the tool is its upload picture feature which allows picture files in “.JPG” formats to be uploaded to the sketchpad.

Sketchpad tool can also be used in conjunction with the RFI module. Most RFIs are supported with sketches, pictures and drawings. Using Sketchpad module as reference to RFIs can improve the understanding of the problem, as well as the pace of the whole process.

Sketchpad tool is adopted as it is, without any modifications. For this sample project, several locations on architectural drawings are marked to demonstrate some of the unclear areas of the drawing. Figure 35 is an example of a sketch which is also linked with a RFI regarding missing dimensions on certain rooms' drawings.

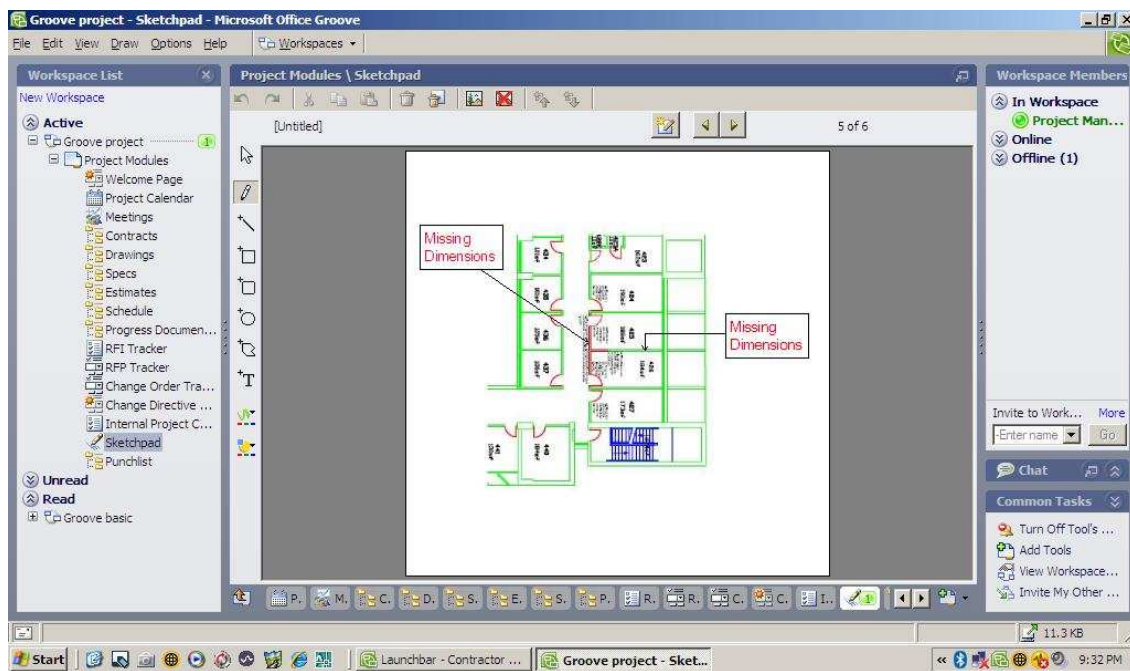







Figure 35. Groove sketchpad module view

This section completes the afore-mentioned objectives of adopting selected Groove tools and modifying them into designated modules for the Construction Industry. Another important objective is structuring limited access contributions around the workspace to gather project input and distribute progress information to project team members (owner, CM, subcontractor, designer and the supplier) and publishing the customized Groove workspace for external use are explained in the next section.

6.2 ACCESS CONTROL AND INFORMATION SHARING

For any PMCS, it is very important to control the access levels to certain modules and templates. The information on certain modules is considered confidential and have to be restricted from all-user access. Particularly, modules carrying information concerning costs, estimates and budgets as well as contracts and internal project communications and documentations are critical for project teams because many of this information are considered proprietary. As a result, following scheme of general access levels is created

as a guideline for project teams in determining authorization levels to each Groove module.

Access Levels	Welcome Page	Calendar	Meetings	Contracts	Drawings	Specs	Estimates	Schedule	Progress D.	RFI Tracker	RFP Tracker	CCO Tracker	CCD Tracker	IPC	Sketchpad	Punch list
 OWNER	✓	✓	✓	x	✓	✓		x	✓	✓	✓	✓	✓		✓	
 CM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
 DESIGNER	✓	✓	✓		✓	✓		x	✓	✓		✓	✓		✓	
 SUBCONTRACTOR	✓	x	x		✓	✓				x	x				x	
 SUPPLIER	✓	x	x		x	x					x				x	

✓ : Full access x : Restricted access

Figure 36. Access levels of project team members to project modules

As Figure 36 demonstrates, each party has different set of access levels to Groove modules. This scheme is created from a Construction Manager (CM) point of view. In other words it is assumed that CM is the main beneficiary of the Groove system. As a result it has full access to each and every module on the system. The Owner as the second beneficiary of the system has full access to majority of the modules and limited access to certain modules such as the contracts and the schedule modules. The Designer or the Architect has limited access to the schedule module and no access to contracts, estimates, RFP, IPC and punch list modules. The Subcontractor, on the other hand, has

full access only to the welcome page, drawings and specs, and limited access to calendar, meeting, RFI, RFP, and sketchpad modules. Supplier has restricted access to modules such as calendar, meetings, drawings, specs, RFP and sketchpad modules.

Although this scheme of access levels provide a general guideline in determining the access levels to custom Groove modules, it is important to note that this scheme can be modified based on the needs and requirements of different projects.

Finally, if construction companies prefer to share their Groove modules and templates developed for one of their projects without project specific data, with the rest of the organization or with teams on other projects, there are several ways of sharing this already customized and ready-to-use Groove template structure. First option is copying all the modules and their templates by excluding project related information and saving it on personal computers. This is done through Groove's "File" menu and then selecting "Save Workspace As..." and "Template..." options. This will save all the modules and their blank templates to the users' computer. After that users have two options in sharing this information with external users. The first option is through Groove workspace invitation process which was described previously in this thesis or by putting a link to a secure web-site and allowing users to download the customized workspaces on their personal computers.

7 CONCLUSION AND DISCUSSION

One of the most challenging tasks in a construction project is to update/maintain project related information. Project management and collaboration system software can provide an effective platform to support this effort by collecting, storing and disseminating information without time and location constraints. In the last decade, several software packages and support systems have been developed to achieve this goal. Although the construction industry is investing in new technologies and ideas, there are adaptation and implementation problems. In addition to system integration and training issues, construction professionals experience usability problems and low levels of comfort. To address these issues, this thesis suggests and illustrates the use of Microsoft Groove software for construction project management and collaboration.

Microsoft Groove provides functionality in all of the features listed for the commonly used management and collaboration packages in the construction industry. Moreover, Groove software offers several additional benefits including real-time synchronization, customization, familiar interface features, reliability, cost-effectiveness, and practical training opportunities. These benefits are discussed in the following sections individually followed by directions for future research.

7.1 REAL-TIME SYNCHRONIZATION

In Microsoft Groove system, any changes in the project documentation and system interface are automatically updated in all the workspaces and the users are alerted of these changes. In most of the other collaboration systems, data updates may require a lengthy procedure while the system wide interface modifications may not be possible requiring new set-up time and effort for every user.

The synchronization process starts with a change on the workspace which creates “deltas”, logical units, on the workspace (Chou, 2006). Once the deltas are introduced to each user’s computer, the synchronization process ends (Chou, 2006). Groove has a built-in logic to manage the synchronization process (Chou, 2006). Though, conflicts may occur in the system when members are working offline and making changes individually on the same tool (Chou, 2006). For structured data, data that is created using one of Groove’s built-in tools and templates, conflicts are very rare since every tool have discrete deltas (Chou, 2006). For unstructured data, data that are not built-in, conflicts may occur if changes are made at the same time on the same document when working offline (Chou, 2006). In this case, Groove alerts the users about the conflict and creates multiple copies of the document leaving the conflict resolution to users (Chou, 2006). In order to limit conflicts, permission settings should be done with caution.

Consequently, synchronization feature allows team players to stay synchronized and get the most up-to-date information at all times. Research shows that, one of the main reasons for underutilization of PMCS is users’ low confidence in finding the most up-to-date information on the system (Hjelt & Bjork, 2007). Working synchronized at all times enables every user to be on the same page hence, contributing significantly to project performance by reducing errors and double-work.

7.2 SYSTEM FLEXIBILITY AND CUSTOMIZATION

Current systems have serious limitations on customizability and flexibility (Augenbroe et al., 2002). This limits the project members’ ability to tailor the system based on the requirements and the needs of the project and dictates one platform for all team members with varying backgrounds, disciplines, and computer experiences. As a result, underutilization of the system and having frustrated team members are inevitable.

One of the key distinctions of Groove system is its unprecedented and incomparable flexible structure for customization. Customization of templates, forms and tools provide user control over the content and design of the system. With Groove, it is possible to create any kind of form and tool based on the needs of the project. Even in a rare case of finding existing tools and template options inadequate, Groove can support users to write their own scripts, further enhancing customizability.

7.3 FAMILIAR INTERFACE AND COMMANDS

Simple to learn and simple to use system mitigates frustration among team players and increases productivity. Related studies show that the most important aspect influencing the rate of adoption in any PMCS is the ease-of-use of the system (Nitithamyong & Skibniewski, 2006).

Groove's visual-based structure enhanced with the use of icons and familiar visual elements, makes the system relatively simple-to-use at the same time making intuitive learning possible for many users. As demonstrated in the sample project, adding and formatting tools/modules and creating forms from scratch in few easy steps would increase the users' self-confidence and reduce frustration among team members. Consecutively, it is very likely that with the adoption of Groove system, many change symptoms such as denial or resistance, can be eliminated or reduced significantly.

Construction industry has a high level of familiarity with Microsoft Office products. This familiarity can help to increase the usability of the system. Groove's similarity to other programs may influence the team players positively to learn and apply faster. Confidence in using computers is directly related to the user's self confidence to learn new technologies and previous experiences play a major role in this development (Davis, 2004). If users have positive past experiences and, as a result, positive attitudes towards

computer systems, the confidence of users are also positively changed leading to faster adoption rates.

Being familiar with the system is an important factor for successful implementation of any PMCS. Since familiarity mandates relevant past experience, users' experiences with other Microsoft products can contribute to the perception of Groove as a relatively familiar system. Becerik's research (2006) shows that construction practitioners are very comfortable in using Microsoft Office products. This supports the expectation that majority of users will also feel familiar with Microsoft Groove system.

7.4 RELIABILITY AND COST EFFECTIVENESS

Reliability of Microsoft Company as a well-established and continuous provider of such technologies reduces the risk of lost-data and system collapses. As in many other services provided by Microsoft, the system is likely to be adjustable and adaptable to technological improvements, which will not necessitate major investments or efforts in the mid to long run.

Microsoft Groove system is a low-cost alternative to other PMCS since it is a standard part of the Microsoft Office 2007 release. Furthermore, Groove can create financial advantages by reducing the need for user training and technical support. For a regular web-based or web-enabled PMCS the need for training is essential to enhance the usability of these systems (Hjelt & Bjork, 2007). However, when the construction industry dynamics are considered, the temporary involvement of certain parties and individuals throughout the project life cycle make it very difficult to provide training for everyone, at all times (Castle, 1999). Nevertheless, the same dynamics of the construction industry necessitate continuous training of the project team for effective adoption of PMCS and successful project completion. Achieving this goal can be cost inefficient for the construction companies.

Since providing continuous training for every changing team member would be unfeasible, many construction companies most likely will fall short in their efforts to meet the needs for training in their projects. Previous research shows that construction companies generally depend on other team members to teach their colleagues the system in place (Hjelt & Bjork, 2007). This can potentially be very frustrating for the new members of the team. Microsoft Office Groove system can substantially reduce the need for continuous training for project participants, hence saving money and time because of its ever-familiar feel and look.

7.5 WORKSPACE PREPARATION AND TRAINING

It is important to recognize two issues that are common for any implementation project. The first issue is that the Groove software, as any other project management and collaboration platform, requires preparation of the project workspace structure. This initial preparation may require time and effort to shape the workspace based on the needs of the construction project. However, as illustrated in this thesis, a basic template structure can be utilized to minimize this initial preparation effort. The second issue is the initial training of the end users who will provide and retrieve information from the workspace. The familiar Microsoft Office look and feel of the software may prove to be very beneficial to address the training needs. Overall, the Groove software offers an alternative approach for project management and collaboration that is easy to use and learn.

7.6 FUTURE STUDIES

Although Groove's customized tools and templates are demonstrated using real construction project output in this thesis, a user test can be conducted to explore the specific features and functionalities of the Groove system. Another opportunity would be

to further develop the existing system with additional tools and modules. The Groove system allows users to write their own scripts and integrate to the system as a result dramatically enhancing the customizability options. Finally, Groove system can also be adopted as an alternative project management and collaboration system for non-construction project types such as facilities management and many others. This will require design and customization of templates and modules for designated project types and industries.

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